Vol. XIX. No. 6 JUNE, 1919 Whole No. 161

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

SMITH & TURTON, Publishers
Publication Office, Mount Morris, Illinois
CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879

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ABOUT HIGH SCHOOL AND COLLEGE BOTANY.

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"Come, let us reorganize," appears to be the popular cry of the teacher and others vitally interested in present-day high school science, especially biology. This is certainly the outstanding feature of much that is being written for our school periodicals today. The agreement appears to be unanimous that something is very unsatisfactory in science teaching in the secondary schools and therefore that something more or less drastic must be done to reorganize the whole matter upon a new basis and with a new or modified ideal in view. World notions about politics, sociology and government are now to be restated and reorganized. Many clergymen agree that even the church must awake to the growing cry for real and effective service in the light of modern times if it is to have a lasting place in the sun or an important role to perform in the new era which appears to be dawning. The readiness of President Wilson to ignore long established custom and precedent has been stimulatingly refreshing, to many. Germany is licked and everyone feels so effervescent over the sudden turn in events that all are eager to participate in such "house-cleaning" questions as may come our way. Our decks have been cleared for action, so let us clean up "the docket" while we are about the job before the powerful wave "to clean things" has passed on and we have complacently wrapped ourselves again in the folds of ante-bellum lethargy. These seem to be more or less common thoughts among teachers and others who have their "ear to the ground" and who plan the science work in our high schools and colleges. And who is there among us who has not sensed very keenly the fact that the profession has been more closely scrutinized during the past decade, and particularly during the war, than ever before in the history of modern education! Be it known, further-

more, that this keenly critical attitude of the public toward the school has not been confined to this side of the Atlantic. Yes, it has come to us 'midst the roar of cannon and the shriek of shell from war-worn Europe. In view of such familiar and far-flung tendencies many of us should perhaps thank our lucky stars that we are still retained as servants of the public school system, for surely schools of all grades have been on trial during these past few years. That we have reacted so favorably is to our eternal credit. That our schools have done much to help win the war, I know full well, but we have even a greater role to perform in the future and that role is to be our most serious and solemn problem.

Considerable wood pulp has been employed during this uncertain period in the dissemination of various and sundry notions as to the reorganization of secondary school science, especially with reference to the biological courses in that science curriculum. I, being a university instructor with little actual experience in secondary school work, might be supposed to have no interest at all in the curricula and methods of the high school. But since I have not dared to publish a high school text and have not in that manner contributed to that particular phase of the "autocratic control" of university over high school, I may possibly have a word of interest for other biological Bolshevists, of which tribe there is not a few. I may be sentenced to the firing squad by the conservatives of our profession by these remarks. Nevertheless, I venture the following paragraphs in all seriousness, although I am not certain but that the paper pulp, necessarily requisitioned for this purpose, might not be better utilized and to far more pragmatic ends in the manufacture of a wash tub or possibly in the fabrication of a liberty dolly for some poor French orphan.

It must be clearly understood that my impressions have been received rather largely from observation of conditions in Nebraska. These convictions have been deepened, however, from knowledge of educational conditions elsewhere. I most sincerely hope that the situation is generally much better abroad than here in my native state.

That high school biology, and particularly botany, is in urgent need of reorganization and that methods of presentation must be considerably modified will be readily admitted by most botanists, I am sure. We have argued about "pure science" and "applied science," about botany and "agricultural botany," about

"practical botany" and "economic botany," etc., until all of the arguments both pro and con have been repeated so often that the whole business has flattened out like a slice of Cycad stem in xylol. And all the time botany, the really "sick man" of the high school curriculum, has become sicker and sicker until it is in fact on the very verge of dissolution. In spite of all of the reactionary forces, we have been content to drum along in the procession with the old stuff and at the same old cadence which we learned at the feet of the masters who introduced that botany of the past generation. I would not criticize that stuff and that cadence in the least, much less those masters, but somehow we sometimes wish that the necessity of modernizing the subject might have been appreciated somewhat earlier than has been the case. Now the degree of modernization necessary may seem exceedingly radical.

When I was an undergraduate student I was taught "always to have a bias in favor of that which was radical," "to guard against the accumulation of permanent tissue" in the brain, to keep the brain always in a "meristem state," as it were. Sometimes I almost fear that my tendency is to follow those excellent admonitions too far afield. I have even felt more or less heretical with reference to the current opinions as to best secondary school botany, and also as to elementary botany in the university. But somehow I have grown to look upon the kind of botany and the point of view of plants taught in many secondary schools and to many Freshman classes in the colleges and universities during the generation just past as closed books, as it were sorts of interesting and withal very valuable contributions in the evolution of the subject. This feeling has doubtless been developed the faster, until it is now almost completely in possession of my soul, by the constantly and rapid coinage of the many upstarts that have been patented and forced into the curricula of our schools. But this is well, and probably as things should be. As touching botany, we have the fragmentation and ramification of the subject of agriculture coming in to lop off one phase after another of plant science, until actually about all that is left for some botanists whom I know is their microscopes and jars of botanical cadavers. The agriculturist has crept in while the botanist slept and has stolen the very soul of his subject. And I would not condemn agriculture in the least for its tendency. On the contrary, I warmly admire the precocity and far-sightedness of the agriculturists.

Surely, if botanists sternly and persistently refuse to teach much of the botany of the field, of the garden, orchard and forest, we cannot wonder, much less object, if the agriculturists attempt to devise ways and means to do these things for themselves. For what other single factor is of as great consequence in the foundation of agriculture as plants and plant life? I am most decidedly not one of those who hold that teaching such botany as this would tend to detract from the *scientific aspects* of the subject. On the contrary, it seems to me that we have a far greater field for teaching the science of plants if we take it more freely to those phases of world life and society dependent upon plant phenomena than if we confine it rather largely to the Pleurococcus-Taraxacum gamut, and to the gametophyte-sporophyte intricacies of the principal plant phyla.

The dangers of the threatened agricultural invasion have been expounded elsewhere, but so far I have been unable to locate any satisfying solution proposed by the botanist to the query: "What are you going to do about it?" The situation seems peculiarly puzzling, for we are prone to discard and to criticize severely the manual of agriculture in which the whole subject of soils is treated without a single reference to the plant or the fact that soils are chiefly important agriculturally because they furnish the medium for the significant development and functions of roots. Perhaps we also shudder when we find another such manual which devotes three-fifths or more of its pages to plant phenomena handled in quite satisfactory form. We are inclined to smile when we hear of the instructor in agriculture who taught that the root is *covered* by root-hairs, and of the county agricultural agent who had the farmer grub out his cherry trees in order to eradicate the cedar apple fungus and the serious disease caused by the same. Our mirth should also be stimulated by the botanist who does not know the common weeds of the fields and gardens and who stoutly insists that it is not a part of his business to know about such trifling matters. Agriculturally speaking, the botanist is also a joke who does not know about the physiology and methods of culture of the common field and garden crops, and something about the maladies to which these crops are subject. Some of these things might be learned in introductory botany, even in the high school, if the botanist only thought so and would set about to teach them more seriously.

The significant fact for botanists to get in all of this lingo is that those interested in agriculture are busily engaged in build-

ing up their own botanical essentials and necessities. The most of such attempts to date are more or less ludicrous, but nevertheless, these people mostly appreciate the fact that there are many fundamental facts about plants that they must know, and they will eventually get these, even if the botanist refuses to supply them. Furthermore, the behavior of these folks surely indicates that they are dissatisfied with the kind of botany that their youngsters are bringing home from the high school, from the college and from the university. This is as plain as day and night. Will the botanists move into the new terrain and supply the goods?

We have simply got to decapitate some of our old botanical pets and to understand that the time for many such "animals" is past. I do not particularly like that word "got," but it is a short word and emphatic in just such usage as this. Decapitation in this sense does not necessarily mean that we are to dispose of the "carcass" in toto. Most of our courses contain some elements of good as do most of our books which need not be discarded, but we might just as well face the problem of a complete rearrangement and reorganization of our subject matter for the use of schools. This means that much must go into some courses and schools that has not been there. We have got to put new life (a lot of it) into botany as did the botanical masters of the past generation. I would direct this remark with all emphasis possible not only to high school botany but also to the elementary or introductory courses in our colleges and universities. I have absolutely no symapthy with the state of mind that concludes that the introductory course in general botany should be given for the particular benefit of some special class or classes of students. I mean by this that a beginning course of greatest benefit and pleasure for the Freshman who plans to prepare for the profession of the forester, the agriculturist, the pharmacist, the physician or for the plain academic student looking for the culture and inspiration from plant phenomena which will illumine his life when college days are done may also be the right kind of course for the student who is thinking of becoming a botanist, or at least of "specializing" in botany. If we were to plan the course with reference to the outlook of the majority of the class in mind we should surely make it broad and of general interest and value to the class as a whole rather than highly particularized for some small fraction of the class. The first course can be handled successfully with such an end in view. The logic and

the pedagogy of such a plan are especially sane when we consider how few students from our large elementary classes actually go on with their botany or who go into some line of work in which a detailed and highly specialized course would be of particular benefit. It is my firm belief that such a course would attract more students from agriculture and from the general colleges to take additional and more advanced courses in the subject.

The aim of the introductory course in college and university, as well as in high school, should be to teach by simple classroom and laboratory methods a true and orderly attitude toward the affairs of life, the scientific attitude, if you please, to teach the really significant and fundamental facts of plant science and to make these methods and these facts emphatic parts of the everyday experience in the life of the student and in the progress of the world about him. There you have the "technical" and the "applied," the "scientific" and the "practical" in a nut-shell! And how different such a course would be from that one in which the drudgery of long and often painful periods at the compound microscope are relieved only by fingering over musty or sodden cadavers to the exclusion of many fundamental facts and phenomena of great importance in the life of the world of plants about us.

The reader must not understand from the foregoing statements, sometimes in mixed figure and more or less facetiously put, that I would necessarily pattern the work in high school botany after the introductory course of the college or university. Such practice might be considered if the latter course were what it should be, but *that* it seldom is. Great and practically irreparable damage has already been done by the unsuspecting high school teacher who has too often attempted to make this adaptation. I suppose that the parroting has been well done sometimes, but mostly, I'm afraid, the parrot went little further than to say "hello" in giving the class in the secondary school a notion of the botany of everyday life, or even possibly of the kind of botany that she had learned (passed in) in the college or university. Too frequently the botany in high school has been a very poor grade of stuff culled from the Freshman course in college, and unfortunately it often happens that that was absolutely all that our poor teacher has had to draw from because she did not go on to advanced work in college. Need we marvel at the present condition of affairs when we become aware of such facts as these? We might help to remedy

the situation if we were allowed to demand more extensive training for prospective teachers.

We are face to face with the necessity of thoroughly revising our introductory courses and also the botanical work of the high school if our subject is to retain an important place in school life. This is particularly true for the high school. We have got to stir up some latent meristem and shelve some of our microscopes or all of them for longer periods, put away some of our pet botanical cadavers and get down to the living, growing, producing plant and the vital relations that it holds to this old storm-tossed world of ours. We have *got* to do these things, I say, or someone else will do them for us and we will be left with the empty sack.

I have read many articles upon this subject published in our school journals during the past few years. Authors have complained bitterly, as I have in the above paragraphs, and the most of them have vaguely suggested remedial measures, as I have, but there has been little definite and tangible in all these statements to indicate exactly what the authors would do in the organization of the new botany. So in order to get at this feature of the dilemma I am willing to include the following outline of suggestions as indicative of some of the features of the reorganized subject matter and the general sequence of treatment as I have them in mind.

SUGGESTED OUTLINES FOR INTRODUCTORY COURSES.

I. The leaf: Its structure, physiology and environment.
- **1. The biological and economic significance of leaves.**
  - **(1) Relations to the plant itself.**
  - **(2) Relations to other organisms, including man.**
- **2. The general external features of leaves.**
- **3. The microscopic anatomy of leaves.**
  - **(1) Epidermis and stomata.**
  - **(2) The mesophyll, chloroplasts, chlorophyll.**
  - **(3) Fibrovascular bundles (veins).**
  - **(4) Variations due to environment.**
    - **a. Sun and shade forms.**
    - **b. Xerophyte and mesophyte.**
    - **c. Economic relations.**
- **4. The growth of leaves.**
  - **(1) General nature of growth in leaves.**
  - **(2) The grass type of growth.**
  - **(3) Relations to culture.**
- **5. Water loss from leaves.**
  - **(1) Demonstration: water vapor, not liquid.**
  - **(2) Relative quantity for different leaves.**
  - **(3) Relation to external conditions.**
    - **a. As to drought, dry air.**
    - **b. As to influence of light.**
  - **(4) Relation of transpiration to stomata.**
  - **(5) Wilting and recovery, drought resistance.**

(6) Adaptations to reduce transpiration.
(7) The pathway of the water.
(8) Transpiration, evaporation and plant communities, types of vegetation and field practice.

6. Nutritive processes in leaves.
   (1) Photosynthesis, carbohydrate manufacture.
      a. Conditions, sources of materials.
      b. Progress and products.
      c. The oxygen output.
      d. The influence of light; the sun.
      e. Properties of chlorophyll.
      f. Test for sugars.
      g. Test for starch in chloroplasts, day vs. night.
      h. Relation to wood, coal, heat, etc.
   (2) Synthesis of proteins and fats.
7. The accumulation of foods made by leaves.
   (1) Starch in the chloroplasts.
   (2) Starch in seeds and fruits.
      a. Micro-examination and tests.
      b. Quantity accumulated.
      c. Processes in manufacture and storage.
      d. Action of enzymes.
   (3) Accumulation of starch in medullary rays and pith.
   (4) Accumulation of sugars in beets, etc.
   (5) Accumulation of proteins, in seeds and fruits.
   (6) Accumulation of fats and oils.
   (7) Foods in roots, bulbs, tubers, etc.
8. Water in food accumulations.
   (1) Relation to storage.
   (2) Relation to injury from heat and cold.
9. Life period of leaves.
   (1) One-season leaves.
   (2) Leaves that persist for several seasons.
10. Uses of leaves as food for man and beast.
11. Uses of leaves for ornamentation.
12. Value of leaves in plant identification.

II. The root: its structure, physiology and environment.
1. The biological and economic significance of roots.
2. The general external features of roots.
   (1) Kinds of roots: fleshy, fibrous and woody.
   (2) Uses of roots.
   (3) Types of root systems.
3. The microscopic anatomy of roots.
   (1) General structure.
   (2) Root-hairs: origin, structure, function.
   (3) The main root and its branches.
   (4) Lack of chlorophyll.
   (5) Position of fibrovascular bundles.
4. Variations of root system due to environment.
   (1) Tap roots.
   (2) Surface roots, shallow soils.
   (3) Root competition.
   (4) Relations among field crops, mixed planting.
   (5) Tillage with reference to root systems.
5. Relations of roots to the soil.
   (1) Origin and nature of soils.
   (2) Physical nature of soils: clay, loam, sand.
      a. Water content.
      b. Air content.
      c. Water capacity.
      d. Percolation.
      e. Temperature.
   (3) Chemical nature of soils.

a. Mineral matter in soil.
b. Organic content.
c. Productiveness of soils, fertility.
(4) Position of roots and root-hairs in soil.
a. Relation to soil solution.
b. Relation to solid materials.
c. Relation to wilting.
(5) Soil requirements of different crops as to:
a. Water requirements.
b. Chemical composition.
c. Bacterial activity.
6. Diffusion and osmosis.
(1) The material income of plants, essential elements.
(2) The material outgo, root excretion.
a. Relation to crop rotation.
b. The phenolphthalein test.
(3) Osmotic pressure and plant distribution.
a. Alkali and saline lands.
b. Salt bushes.
7. Storage of foods in roots and other underground structures.
(1) Roots proper, sweet potato, etc.
(2) Bulbs, corms, onion, crocus, etc.
(3) Rhizomes, canna, ferns, etc.
8. Growth of roots.
(1) In length, relation to soil.
(2) In thickness, relation to age.
(3) Adventitious roots.
a. Value in propagation, cuttings, etc.
b. Repair after injury from tillage.
9. Tillage as affecting water content and root development.
10. Dry farming practices.
(1) Affecting the soil.
(2) Requirements of successful plants.
11. Irrigation.
III. The stem: its structure, physiology and environment.
1. The biological and economic significance of stems.
(1) Leaf exposure.
(2) Useful products.
2. The general external features of stems.
(1) Herbaceous stems.
(2) Woody stems, bark and wood, cambium.
(3) Vines, tendrils, etc.
3. Microscopic structure of stems.
(1) The herbaceous stem.
a. Dicotyledons.
b. Monocotyledons.
(2) The woody stem.
a. Wood.
b. Bark.
c. Cambium.
d. Pith.
e. Medullary rays.
(3) The growth of stems.
a. The woody cylinder.
b. Annual rings: relation to age.
c. Growth in height.
4. Movement of water and food in stems.
(1) Function of the xylem.
(2) Function of the phloem.
(3) Storage of foods in stems.
5. Wood: its structure and uses.
(1) Lumber: kinds and sources.
a. Broadleaf timbers.

b. Coniferous woods.
(2) Other woods and their uses.
a. Paper pulp, willows, fuel, etc.
b. Small articles of wood.
(3) Relation of structure of wood to:
a. The "grain."
b. Utilization.
c. Possibility of finishing.
(4) Indirect products, turpentine, etc.
6. Textile fibers: flax, hemp, etc.
7. Pruning.
(1) Relation to structure of stems.
(2) Relation to physiology of stems.
8. Value of stem (twigs and buds) characteristics in plant identification.
9. Grafting and budding.

IV. The flower: its structure, physiology and environment.
1. Biological and economic significance of flowers.
2. Technical and popular notions of flowers.
3. The general gross anatomy of flowers.
(1) The perianth.
(2) The stamens: pollination.
(3) The pistils or carpels.
(4) Functions of the parts.
4. The sex organs of flowering plants.
(1) Value in study of sexuality in general.
(2) Prove role of pollen and ovule.
(3) Cell division.
(4) Relation to breeding and inheritance.
a. Artificial pollination.
b. Production of new forms.
c. Mendel's laws of inheritance.
5. Relations of fruits and seeds to flowers.
6. Flower types and their variations.
(1) Evolutionary principles.
(2) Value of adaptations.
(3) Use in classification.
7. Commercial value of flowers.
(1) Common forms.
(2) Their propagation.

V. The seed and fruit: their structure, physiology and environment.
1. Biological and economic significance of seeds and fruits.
(1) The perpetuation of the species.
(2) Food supplies for man and beast.
2. The number of seeds and fruits produced.
(1) Efficiency of seed production.
3. The common types or kinds of fruits and seeds.
(1) Dry fruits.
a. The various kinds and structure.
(2) Fleshy fruits.
a. The various kinds and structure.
4. Botanical and popular ideas of fruits.
5. The parts of seeds, and variations.
6. The food content of seeds and fruits.
(1) Fruits used as whole, seeds not important.
(2) Seeds the principal value in fruits.
a. Water content.
b. Starch content: iodine test.
c. Sugar content: Fehling test.
d. Protein content: Millon and Biuret tests.
e. Fats and oils: alcanna and paper tests.
7. Quantity production of seeds and fruits as animal foods.
8. The germination of seeds.

(1) What is it?
(2) Dependent conditions.
a. Water relations.
b. Temperature relation.
c. Depth and air relations.
d. Conditions in field and garden.
(3) Behavior of the seed during germination.
a. Function of the cotyledons.
b. Fate of the Cotyledons.
c. Pressure exerted: significance.
(4) Respiration: importance.
(5) Enzymes and their importance.
9. Contrast seeds with bulbs, tubers, etc., in propagation
10. Water content relations of seeds.
(1) In storage.
(2) Injury from heat or cold.
a. Early frosts and seed corn, etc.
11. Dissemination of fruits and seeds.
(1) Modifications of structure for migration.
(2) Agents in migration.
(3) Competition and survival among invaders.
12. Seed selection, contamination.
VI. Some ecological botany.
1. The plant habitat.
(1) Its characterization.
(2) Compare with animal environment.
a. Kinds of habitats.
b. Conditions within the habitat.
(a) Soil conditions or factors.
(b) Air (climatic) factors.
2. Plant communities.
(1) Types of communities.
a. Forests and bushland.
b. Grasslands and plains.
c. Marshes, swamps and bogs.
d. Cultural communities: fields.
(2) Origin and development.
a. Migration: methods and agents.
b. Establishment in the new home.
(3) The structure (composition) of communities.
(4) Plant succession: natural plant rotation.
a. The "going back" of broken or logged areas.
b. Steps and changes in succession.
c. Illustrations of succession.
d. Economic value of a knowledge of succession
(a) In forestry and grazing.
(b) In agriculture.
(5) Sanitary relations of plant communities.
a. Swamps: mosquitoes, yellow fever.
b. Contamination of water supplies by algae, etc.
(6) Relation of plant communities to game and recreation.
a. Common parks.
b. The national forests.
c. National parks.
3. The principal major plant communities of North America and their products.
(1) The Arctic-Alpine tundra region.
(2) The eastern forest region.
a. The northeastern coniferous forest.
b. The central hardwoods forest.
c. The southeastern coniferous forest.
(3) The Prairie-Plains grasslands region.

(4) The Rocky Mountain forest region.
(5) The Great Basin bushland and desert region.
(6) The Pacific Coast forest region.
4. The indicator value of natural plant communities.
(1) As to soil and climate.
(2) As to possible crop production of other utilization.

VII. The major groups of plants, evolutionary notions, etc.
1. General statement of principles.
(1) Of evolution in general.
(2) Of the plant world.
(3) The notions of Darwin, Wallace, Lamarck, etc.
(4) Plant life-histories and their meaning to biology.
2. The principal subdivisions of the plant world; their life-histories.
(1) Thallophytes.
a. The algae: Spirogyra, Oedogonium, Pleurococcus.
(a) Structure, physiology, life-history.
(b) Relation to water supplies.
b. The fungi.
(a) Phycomycetes: Mucor, Peronospora; diseases.
(b) Ascomycetes: Peziza, Plowrightia, lichens, yeasts (fermentation); diseases.
(c) Basidiomycetes: Agaricus, Lycoperdon, rusts, smuts; diseases.
(d) Schizomycetes; the bacteria: relation to disease, death, decay, nitrogen cycle, etc.
(2) Bryophytes.
a. The liverworts: Marchantia or Anthoceros.
b. The mosses: Funaria or Polytrichum.
(3) Pteridophytes: ferns and horsetails.
(4) Gymnosperms: the pines, etc.
(5) Angiosperms: flowering plants.
a. Monocotyledons: A lily and a grass.
b. Dicotyledons: A rose, a legume, a mint or snapdragon, a phlox, a composite.
c. Complete life-history of a flowering plant.

VIII. Some plant pathology: sickness among plants.
1. The fact of disease in plants.
2. Plants are living things and:
(1) May be well and normal.
(2) May be sick, and may die.
3. The nature of disease in plants.
4. The scope of plant pathology.
5. Causes of plant diseases.
(1) Organic causes (living organisms).
a. Fungi and bacteria.
b. Insects and other animals.
(2) Inorganic causes (causes in the non-living world).
a. Unfavorable soil conditions.
b. Unfavorable atmospheric conditions.
6. The symptoms of plant diseases, their recognition.
(1) Discolorations or abnormal changes in color.
(2) Galls, tumors, excrescences.
(3) Rotting, decay.
(4) Arrested development.
7. Losses due to common diseases.
8. The necessity of control or eradication.
9. General possibilities in the matter of control.
(1) Principles of combat.
(2) Common fungicides and insecticides.
10. Some representative plant diseases.

(1) Oat smut.
(2) Brown rot of stone fruits.
(3) Wheat rusts.
(4) Potato blights.
(5) Apple fire-blight.
(6) Powdery mildew of the vine.
(7) Cedar apple.
(8) Damping-off.
(9) Crown gall.
(10) Black rot of cabbage.

11. Method of study for each disease.
(1) Symptoms.
(2) Cause: life-history of fungus or bacterium.
(3) Economic relations, losses.
(4) Control or method of treatment.

IX. Some common weeds.
1. What is a weed?
2. Damage done by weeds.
(1) Take water and food materials from other plants.
(2) Dry out soils.
(3) Shade and crowd other plants.
(4) Spread disease.
3. Kinds of weeds.
(1) Annual weeds, vines, etc.
(2) Perennial weeds.
(3) Woody weeds (tree weeds).
4. Dissemination of weeds.
5. Methods of eradication or control.
(1) Cultivation.
(2) Grubbing: extreme cultivation.
(3) Chemical treatment.
(4) Rotation of crops.
6. Good that weeds may do.
(1) Supply food for birds (seeds).
(2) Hold soil against erosion.
(3) Prepare way for later stages in succession.
(4) Add organic matter to soil.

X. The classification of flowering plants.
1. Principles of classification in flowering plants.
(1) Structure of a "low" type of flower.
(2) Structure of a "high" type of flower.
(3) Intermediate types.
(4) Importance of number, shape, position, arrangement, etc., of flower parts as indicating relationship.
(5) The meaning of orders, families, genera and species.
(6) The necessity of classification.
2. Important economic groups, types and economic species
(1) Among Monocotyledons.
a. Lilies, irises.
b. Grasses, native and cultivated.
(a) Some native grasses.
(b) The cereals.
(2) Among Dicotyledons.
a. The rose group: apples, plums, cherries, raspberries.
b. The legume group: alfalfa, clover, peas, beans.
c. The parsleys and celery.
d. The morning glories and pinks.
e. The snapdragons and mints.
f. The composites.
g. Trees and shrubs.
(a) Field study in fall, winter and spring.

(b) Learn to know common ones.
(c) Uses, lumber and other woods.
(d) Ornamentals and fruit.

h. The identification of common weeds.

The criticism may be made with reference to the above outline that the outline is nothing but essentially a fair table of contents for some book on general botany, with certain modifications, possibly of some few of our better texts. This criticism may be more or less in order and yet a careful study of the outline will reveal the fact that there are some conspicuous modifications as compared to the typical course as given in the schools. I am willing to admit that we may use much of the good from the old botany. I would not be so dogmatic as to discard the subject matter and methods of the past generation in toto. I am quite sure, however, that although the text used may treat of practically all of the features indicated in the outline, nevertheless the tendency in actually teaching botany is to subordinate all of the other phases of the subject to a detailed consideration of the principal groups of the plant world from an evolutionary point of view, in which morphology is particularly stressed to the exclusion of much fundamental matter. Too much microscope, algae and cells is probably the nucleus of my complaint! Believing that this is bad, I have deliberately reduced those phases of the subject to the minimum and have stressed more than is commonly done the physiological and ecological phases and have interpolated items on every hand which particularly should direct the attention of the student to the economic and the utilitarian values of the subject. This is a deliberate attempt to make the plant and its life an object of everyday interest and value, if you please. I do not believe that such treatment will detract in the least from the scientific features or the teaching values of the subject. There are probably some who would go even further than I have indicated in this direction.

The details of the numerous exercises and lessons possible as suggested by the outline, the time allotted to the various sections, the adaptation of the sections of the outline to the various grades of instruction, possible variations in the sequence of treatment, and the whole problem of the method of teaching are not within the scope of this paper. However, these are exceedingly important matters for the teacher to consider.

DIFFUSION, OSMOTIC PRESSURE, AND IMBIBITION IN HIGH SCHOOL BIOLOGY.

By Aleita Hopping,
DeWitt Clinton High School, New York City.

(Continued from May.)

Osmotic Pressure and Gas Pressure.

As is well known, van't Hoff, a physicist, using Pfeffer's direct determinations of osmotic pressure, arrived at the equation $P = nRT/v$, where P is the osmotic pressure, T the absolute temperature, R a constant, n the number of gram molecules of solute in volume v. This is the well known equation for gases. The equation holds exactly only for dilute solutions. Osmotic pressure, then, may be regarded as equal to the pressure the solute would exert, as a gas, occupying the volume of the solution or of the solvent. Since gas pressure is considered to be due to the kinetic energy of moving particles, it follows that a similar explanation may be offered for osmotic pressure, namely, that the pressure is exerted by the solute particles in the solution.

Many determinations of the osmotic pressure of substances in solution have been made, and it has been found that the calculated values, using the gas pressure formula, do not agree with the observed values, in case of concentrated solutions. For this reason, the simple form of the gas pressure theory has has been modified to meet these conditions, but the validity of the theory has not, of course, been altered. Substances in solution undergo a chemical union with water (or solvent), producing stable hydrates, and thus reducing the volume of the solvent. Cane sugar forms a hydrate with water and is represented by the formula $C_{12}H_{22}O_{11}.6H_2O$; the volume occupied by the solute must therefore be considered as the volume of the unassociated solvent, not as the volume of the solution.

The rapidity of movement of sugar molecules through a membrane is probably influenced by the attractive forces that exist between the molecules of sugar and of water. When a substance is dissolved in water, ordinarily the surface tension of the water is lowered. When a solution and solvent are separated by a membrane, permeable to the solvent, the higher surface tension of the solvent would cause a movement through the membrane into the solution.

Imbibition.

The colloids, like glue, gelatine, albumin, gum arabic, etc., all absorb water to a marked extent. Silicic acid in the colloidal

state has a solid form and yet consists of 90 per cent. of water. Colloids absorb water and swell, and this process is called imbibition. There is usually a limit to the amount of swelling, though in many substances the form of the swelling body merely changes from the solid to the liquid condition. In experiments with Laminaria, a seaweed, which behaves like a colloid, parts of this plant absorbed water and swelled 300 per cent., by volume under one atmosphere pressure, and even under forty-one atmospheres, it increased 16 per cent. of its volume, thus expanding under a pressure of 615 pounds per square inch. This process is accompanied by liberation of heat, which is called heat of imbibition. When one gram of dry gelatine swells, 5.7 calories of heat are given out. In case of gum arabic this is equal to 9.0 calories.[18]

In imbibition the absorption of water may be due to capillary forces, acting in very small spaces; as is well known, some substances wet one another, like water and glass, while other substances, like mercury and glass, do not: In cases where substances do wet one another the forces of adhesion, the tendency of unlike substances to stay together, comes into play. The molecules of water are attracted by the glass, and in the case of capillary tubes, water rises in the tube. When substances imbibe water, it is understood that the water molecules are absorbed in and become regularly scattered about the molecules of the substance, the two masses remaining in the solid condition. The amount of water held in this way has a limit; if this limit is exceeded as by raising of the temperature, the mass passes into a liquid condition. Thus gelatine will absorb water and remain a stiff jelly; if this is heated it becomes a liquid.

It will be remembered that the osmotic pressure of crystalloids is proportional to the concentration and the temperature. When mixtures are studied, the effect is found to be purely additive, the osmotic pressure of the second substance is added to that of the first. The osmotic pressure of colloids is, of course, very low, and is very unstable. There is no definite relation between the osmotic pressure and temperature or concentration. The influence of added substances is various. Acids and alkalies, even in very dilute solution, markedly increase the osmotic pressure, whereas salts always decrease it. Thus a 1.25 per cent solution of albumin gave an osmotic pressure of 21.6 mm. of a mercury column, but when a trace of copper chloride was

[18]Hatschek, Emil, *An Introduction to the Physics and Chemistry of Colloids*, Philadelphia, 1916, pages 59-60.

added this value fell to 1.6 mm. It is true also that substances that decrease osmotic pressure of colloids also decrease their swelling and the action is almost identical.[19] From these facts, as well as others, it is suggested that the structure of the material undergoing swelling acts as a selectively permeable membrane, and that osmosis of colloid solutions might well be termed a swelling of liquids in contrast to the usual swelling of solids.

Diffusion and Osmotic Pressure in Biology.

Diffusion plays a very important role in biology. In cases where there are no mass movements of materials, these movements are in general due to diffusion. In plants, particularly, diffusion plays a very important part. Here mass movements of liquids within the plant are confined mostly to the movement of water, in the transpiration stream, and in protoplasmic streaming. Convection currents are probably active to some extent. The entrance of oxygen and carbon dioxide into leaves probably occurs mostly by gas diffusion. If the cell walls lining the air spaces are moist the gases probably dissolve and then pass into the cells by solution diffusion, which we have seen is in no essential way different from gas diffusion. Stomata in the leaves, and the lenticels in the bark, allow gases to enter into and pass out of the leaves and the stem, and thus to reach the cells by diffusion. The gases are dissolved there, in the liquid parts of the cells. Mineral matter dissolved in the soil water may pass by diffusion into the cells, though it is more probable that it is moved along with soil water in the transpiration stream, or absorbed by the colloids of the cell contents.

In animals, diffusion plays an important role. According to Fischer[20]; the absorption of foods from the lumen of the food tube is in large part due to diffusion. The food in the mouth, stomach, and intestine is partially digested, the colloidal substances, like starch, fat, and protein, which cannot diffuse through membranes, being changed into the crystalloids, sugar, fatty acids, and glycerine, and peptone. Fat when emulsified is able to pass through the intestinal membranes, though it is still in the colloidal condition. The membranes of the intestine are quite permeable to sugar, peptone, glycerine, and fatty acids, and seem to offer little or no resistance to diffusion. These

[19] Ostwald, Wolfgang, *Handbook of Colloid Chemistry*, translated from the third German edition by Martin H. Fischer, 1915.

[20] Fischer, Martin, *Physiology of Alimentation*, New York, 1907.

substances are all in great quantity in the food tube, and rapidly diffuse out as a result. The membranes, of course, must be regarded as consisting not merely of the outer layer of protoplasm in the individual cells, but may be regarded as a whole series of cells acting together. The digested foods pass by diffusion through the walls of the villi and pass into the blood and lymph, and eventually are carried by mass movements of the blood to all parts of the body.

In the tissues, the process of diffusion occurs again, the food passing from the blood, where it is in a concentrated condition, into lymph, and then into the protoplasm, where it is oxidized and changed into carbon dioxide, urea, etc. The carbon dioxide and urea diffuse out of the cells, into the lymph or capillaries, and then are carried by mass movements to the lungs. In the tissues, the nutrients from the plasma pass into the lymph through the membranes of the capillaries and into the protoplasm. In the lungs, the carbon dioxide by solution diffusion passes into films of mucus and water lining the air sacs, and then by gas diffusion into the air spaces. By mass movements due to contraction of the chest cavity, it is expelled out of the body, into the surrounding air. The excretion of urea cannot be thus easily explained, for in the kidneys, urea leaves the blood, where there is relatively, little of it, and passes into the kidneys, where there is an accumulation of it, and is thus seen to be not a movement of diffusion. The secretion of materials by colloidal substances will probably be called upon to explain this process.

The role of somotic pressure in plants and animals is still much discussed. The osmotic value of the blood is almost as constant as the body temperature. In different animals the osmotic value of the blood is very different. When liquids are injected into the circulatory system after loss of blood, the solutions used are so made as to have an osmotic value, corresponding to that of the blood.

Turgidity of cells may be due to imbibition, attraction of cell colloids for water, or to osmotic pressure. It has been explained how colloids absorb water and swell, developing great pressures. The swelling pressure of imbibition is very important in explaining the pressures developed during the growth of roots and delicate plant parts.

When a plant cell is surrounded by a solution of greater concentration than that contained within its vacuole, the phenomenon of plasmolysis occurs. The greater osmotic pressure of the

solutes outside, together with the slight resilience of the protoplasm, causes a contraction of the protoplasm, which separates from the enclosing cellulose wall. If the process of plasmolysis is complete, the vacuole may disappear, practically all the water passing out. In such cases, the protoplasm takes the form of a sphere, lying at the middle or side of the cell. Plasmolysis usually occurs within a very few minutes after the cell has been immersed in the solution. When a solution of known concentration just causes plasmolysis, it follows that the osmotic value of the cell sap must then be equal to that of the solution surrounding the cell. Here is a way to find the concentration of the cell sap.

When an organ of a plant is placed in a solution, the osmotic value of which is less than that of the cell contents, and to which the cell membrane is impermeable, or slowly permeable, water passes from outside through the membranes into the cells of the organ, and the organ is swollen or turgid. If the outer solution is replaced by a solution having a higher osmotic value than the cell contents, water passes out of the cells into the solution and the organ is wilted or plasmolysed. Under natural conditions, the organs of the plant body are surrounded by liquids, the osmotic pressure of which is lower than that of the cell contents, so they are usually turgid, or they are surrounded by gases. Of course, when water is removed by any other means, as by evaporation, the leaves or cells also wilt, and lose their turgor.

To some substances protoplasm is quite impermeable, to the majority of substances it is very slightly permeable, and to some substances it is usually very readily permeable. Cane sugar, glucose, and NaCl ordinarily penetrate cells to some extent, though slowly. Glycerine and urea penetrate with great readiness. Ethyl alcohol, acetone, caffein, formaldehyde, penetrate cells so rapidly that no plasmolysis occurs.

Both imbibition and osmotic pressure are important in the retention of form of plants and animals, in mechanical support, growth, and in the performance of work by growing parts.

Changes in the osmotic value of a solution may change the extent to which water is absorbed, increasing or decreasing absorption. Changes in the water-attracting power of colloids may also have the same effect. Colloids are altered by presence of slight traces of salts, acids, etc. Great quantities of water are absorbed daily from the alimentary tract, four or five liters in the course of a day, in some cases. Some of this absorption

is due to differences in osmotic pressure, but probably much more is due to the enormous affinity of colloids for water. Protoplasm is, of course, a mixture of many substances in the colloidal condition, and as is well known consists of about 80-90 per cent. of water.

Absorption of water by roots is probably due as much to imbibition of water by colloids as to diffusion or "osmosis."

CONCLUSION.

Since osmosis is the diffusion of substances through membranes, the word is unnecessary, and confusing, and ought to be dropped. The direction of osmotic movements should not be described as being from the "less to the more dense." Diffusion of substances in solution, and diffusion of gases, ought to be taught as thoroughly as possible, the laws governing it, and the causes underlying it, that is, the intrinsic or kinetic energy of molecules.

Most movements of materials in the body when the substances are in the molecular conditions are due to diffusion. The absorption of water by colloids, imbibition, should be studied. Osmotic pressure should be explained upon the basis of the diffusion of dissolved substances and should be shown to be due to the kinetic energy of the molecules. Osmotic pressure and imbibition should be studied only in advanced classes. Diffusion should be studied in elementary and advanced classes.

The role of osmotic pressure, imbibition, and diffusion in plants and animals should be taken up, the importance in retention of form of cells, and delicate parts, turgidity of cells, and organs, etc. The diffusion of substances such as foods and gases should also be studied.

OUTLINE.

NOTE: Single star (*) denotes topics for elementary work, double star (**) indicates subjects to be taken up in advanced work.

Theory of Diffusion, Osmotic Pressure, Imbibition.

*A.

I. DIFFUSION.

(*a*.) Diffusion of substances in the air
- (1). Steam in a room
- (2). Perfume of flowers
- (3). Cigar smoke
- (4). Mustard gas

(*b*). Diffusion of substances dissolved in water
- (1). Ink in water
- (2). Copper sulphate in water
- (3). Sugar in water

(*c*). Direction of diffusion
Substances diffuse from regions of higher to those of lower concentration
(*d*). Diffusion through a membrane
(1). Thistle tube, parchment paper, filled with starch
(2). Same, filled with sugar
(3). Sugar diffuses through membrane, starch does not

**II. OSMOTIC PRESSURE
(*a*). Sugar in thistle tube, parchment paper
(1). Note rise of liquid in tube
(2). Test for sugar
(3). Note rapid passage of H_2O through membrane and slower passage of sugar
(*b*). Direction of flow
(1). Solvent flows into solution through semipermeable membrane into solute, and a hydrostatic pressure is developed which is a measure of the osmotic pressure
(*c*) Explanation
(1) H_2O diffuses from where there is much of it to where there is little of it
(2) Sugar diffuses out if membrane is permeable
(3) Sugar may attract water and cause absorption

**III. IMBIBITION
(*a*) Experiment
Glue or gelatine or egg albumin separated from water by a parchment paper membrane
(*b*) Direction of flow
Water is absorbed by the colloid, which cannot pass through the membrane
(*c*) Explanation
Glue and egg albumin are colloids and absorb water (imbibition), this due to attraction between the molecules, or may also be due to diffusion of the water molecules

B. IMPORTANCE OF DIFFUSION, OSMOTIC PRESSURE AND IMBIBITION

*I. DIFFUSION
1. In plants
(*a*) Absorption of mineral matter
Here membrane is permeable to salts and to water, water and mineral matter moves from denser to more dilute (outer solution of soil, into cell sap)
(*b*) In leaves
Gaseous exchange:
In night—
(1) Much O in air, little in leaves, O diffuses in
(2) Much CO_2 in leaves, little in air, CO_2 diffuses out
In day—
(3) Much O in leaves, much in air, may stay in or go out, depending on the rate of photosynthesis
(4) Much CO_2 in leaves, some in air, but CO_2 is used up faster than produced, so some moves in from air
2. In animals
(*a*) Passage of food in small intestine into blood and villi, and from blood into cells
(1) Membranes of blood vessels and of villi are permeable to peptone, sugar, emulsion of fat. Impermeable to proteid, starch, fat. Dissolved peptone, sugar, and emulsified fat, concentrated in small intestine, diffuse into lymph and blood, where there is little of these substances
(2) Passage of food from blood into lymph spaces and into cells
More of dissolved food in blood, in capillaries, less in lymph

and cells, so passage of these substances by diffusion from blood into lymph and then into cells

(b) Exchange of O and CO_2 in lungs and tissues
 (1) In lungs
  (a) Membranes permeable to both CO_2 and O
  (b) Much CO_2 in blood, little in air; CO_2 passes from blood into air
  (c) Much O in air, little in blood, O passes into blood from air
 (2) In tissues
  (a) Membranes permeable to each
  (b) Much O in blood, little in cells, O passes from blood into cells
  (c) Much CO_2 in cells, less in blood, CO_2 passes from lymph and cells into blood
(c) Gaseous exchange in fish
 (1) Membranes of gill fringe and of capillaries permeable
 (2) Much dissolved O in water, little CO_2
 (3) O diffuses into blood, CO_2 diffuses out

**II. OSMOTIC PRESSURE
1. In plants
 (a) Absorption of water by roots may cause rise of water in stem; this due to imbibition also
 (b) Plasmolysis and turgidity
  (1) Place leaves in strong sugar solution, they wilt, water passes from leaves into sugar solution
  (2) Place these leaves in water, they revive; water passes into leaves
  (3) Pressure resulting in turgidity due to diffusion pressure of solute which cannot pass through semipermeable membranes, or to attraction of solute for water
  (4) Importance of turgidity and osmotic pressure in retention of form and shape of plants
2. In animals
 (a) Plasmolysis and turgidity
  (See Osmotic Pressure in plants)
 (b) Osmotic pressure of blood is almost as constant as body temperature, different in different animals
 (c) Importance of osmotic pressure in injection of solutions into blood

**III. IMBIBITION
1. In plants
 Absorption of water by protoplasm
 Energy of growth
2. In animals
 Absorption of water by protoplasm
 Energy of growth

BOYS' AND GIRLS' CLUB MOVEMENT.

The educational value of the boys' and girls' club movement is none the less because of the emphasis that the clubs place upon productive work and the earning of money. Against "child labor" there was been a merited protest, for child labor is the deliberate premature exploitation of the Nation's most precious resources. But to exclude boys and girls from all participation in productive work would be to deprive them of the kind of experience that will best fit them to "pull their own weight" when the time comes for them to take the oars. The problem is not to keep children away from work, but rather to induct them into it gradually and with an eye single to its educational influence. The boys' and girls' clubs, like the School Garden Army, represent an organized and intelligent effort to solve this problem.—[*School Service.*

SEX EDUCATION IN BIOLOGY COURSES.

BY VAUGHAN MACCAUGHEY,
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Much has been written upon sex-education as a special subject for instruction. The present writer, basing his conclusions upon a decade's experience in biological teaching, desires to emphasize the desirability—indeed, *necessity*—of giving sex-education a normal place in all general biological courses. Special methods of propaganda and teaching, in great variety, must and will be fully used, of course, before an effectual national program of sex-education is comprehensively developed. In the meanwhile, however, certain phases of sex-education must attain *recognized positions* in the general elementary, secondary, collegiate, and university biological courses.

Every teacher of the biological sciences recognizes that at present some "sex," education is given, more or less indirectly, in these courses. The main task which lies before biologists and educators is the incorporation of well-organized, accurate, and *non-sensational* subject matter into existing biological courses. This subject matter will be given as integral and normal parts of the courses, without more or less emphasis than that accorded to other important topics. Bigelow's concise statement is worth quoting here in full: "I certainly do not believe in completely revamping biological science for the purposes of sex-education. It is better not to 'spoil' a course by over-emphasis on sex, for much of the value of biology as a basis for sex-education is the fact that sex appears gradually and naturally and far away from human relations. This impersonal approach will be lost if the course in biology seems to revolve around sex-education, for that will make sex too prominent." (Maurice A. Bigelow, *Sex-Education*, Macmillan, 1916, 251 pp., with bibliography. *Every biology teacher* should know this book.)

The writer believes that the following themes should have a place in every general biological course, whether of secondary or collegiate grade: "The Origin and Nature of Sex"; "The Evolution of the Sex Mechanism"; "The Nature and Functions of the Internal Sex Organs"; "The Elements of Human Embryology"; "Venereal Disease"; some of the simpler "Basic Principles of Genetics, Heredity, and Eugenics"; "Sex Control in Human Society"; and especially those social aspects that deal with the encouragement of worthy stocks and the elimination of defectives.

The literature on these themes is voluminous, but much of it is extremely technical, and much is purely pathological. The writer completely agrees with Bigelow and other students, that entirely *too much* popular emphasis has been placed upon sex pathology and venereal diseases, and not enough upon the romantic and constructive phases of sex life. The basis of all American life and institutions is the normal Christian American home; sex-education must place its main emphasis upon sweet and sane and rational life, and not on pathology.

Our standard biological courses have not adequately recognized *the psychic life*, and the psychic side of sex problems, the elements of will, motivation, and moral control. The rational control of sex life must be ever based upon accurate knowledge of the "plain facts," but the moral impulses must be quickened and strengthened. The biology teacher of the right sort, in the quiet routine of the course, can make a far more effective and desirable presentation of the facts and principles of sex, than can be made anywhere else except in the home. The personality of the teacher is, of course, a factor of outstanding importance, and Bigelow rightly emphasizes the dangers of pessimism, sensationalism, and other ills of defective personality.

These lessons come naturally in the latter part of the course, after the students have become familiar with the general viewpoint of biology and the nature and development of the animal mechanism. In the plant series the moss and fern life cycles afford appropriate points for a discussion of the role of sex. In the animal series, the evolution of the mammals leads naturally to the prenatal period, and thence to a sound discussion of eugenic principles.

The literature of sex-education contains a large amount of controversial material concerning the relative merits of segregation vs. mixed groups. It is the writer's opinion that as the subject matter and methods of sex-education become more and more clearly formulated, and as it acquires its rightful place in the curriculum and in the community, instruction will be in terms of segregated and well-classified groups. In the high school and early college years much of the purely biological data of sex-education can be taught successfully to mixed classes, but as Bigelow states (loc. cit. p. 147), "separate classes are desirable if the course is made to include all the important facts that college graduates should know concerning human reproduction."

The most important step in the sex-education program of any

school or community is to *begin*. In the light of our twentieth century knowledge, the prevailing school and home policy of silence, evasion, and downright lying, is absolutely criminal. For the average adolescent boy and girl all other biological data come from accurate sources; but his or her sex-knowledge comes from the gutter, the back alley, and the social sewers. High school and college teachers, and teachers in the upper grades, can perform pioneer educational work of the most vital, far-reaching, and racially valuable character, by giving their serious attention to this outstanding problem of sex-instruction in our existing biological courses. This is only one sector of the battle line, but it is a sector of strategic and enduring importance. Every teacher of biology who is *not* thinking and studying and working along these lines, is not living up to the racial ideals of genuine Americanism.

The following select bibiography may be of interest:

Publications of the *American Social Hygiene Association*, 105 West 40th St., New York City.
M. A. Bigelow: *Sex-Education*. Macmillan.
Patrick Geddes and J. A. Thompson: *Sex*. Holt, $0.50.
W. T. Foster and others: *The Social Emergency*. Houghton, $1.35.
E. B. Lowry: *Teaching Sex-Hygiene in the Public Schools*. Forbes, $0.50.
Prince A. Morrow: *Teaching Sex-Hygiene*. Amer. Soc. Hyg. Assoc.
Ira S. Wile: *Sex-Education*. Duffield, $1.00.
C. W. Saleeby: *Parenthood and Race Culture*. Moffatt, Yard. $2.50.
C. B. Davenport: *Heredity in Relation to Eugenics*. Holt, $2.00.

THE STATES AND CHILD LABOR.

"The States and Child Labor" just published by the Children's Bureau of the Department of Labor in cooperation with the Child Conservation Section of the Field Division of the Council of National Defense, is a most helpful summary by states of the child labor laws now on the statute books. The minimum age requirements for wage earning, the number of hours children are permitted to work a week, night work prohibitions, prohibitions of labor in mines and quarries, compulsory school attendance laws, and the conditions under which children are exempted from school attendance, are all set forth in this publication.

Teachers desiring to use the information contained in this pamphlet should send for Children's Year Leaflet Number 13 to the Children's Bureau, Department of Labor, Washington, D. C.—[*School Service*.

PREPARE FUTURE FARMERS AND HOME-MAKERS.

To demonstrate through farm boys and girls the most efficient and, in the end, the easiest methods of farming and housekeeping, is the first aim of the boys' and girls' club work conducted by the United States Department of Agriculture and the cooperating agricultural colleges in the States. The club work is not a mere training of future farmers and farmer women; it is a constant demonstration of better methods for the benefit of both father and son, mother and daughter.—[*School Service*.

WHY NOT NOW?[1]

By Hilton Ira Jones,
Stillwater, Oklahoma.

"How much is this tie, sir?" I asked a London clothier. "Two and six," he answered. I gave him a five-pound note. How much change should I have received? You don't know, neither did I, and because it would have taken me several minutes with pencil and paper to figure it out, same as you, I took what he gave me, and to this day I am not sure whether he short-changed me or not. I have a sneaking feeling that he did, at least I know London cabbies do. They know a foreigner used to a decimal currency cannot fathom the mysteries of English money.

Down in La Paz, Bolivia, a wealthy rubber grower was looking over a Sears-Roebuck catalogue and one of a German house. He finally ordered his stuff from the German company at a higher price, not counting the freight. "Why did you buy from Germany" he was asked, "when the United States is closer?" "Simply because the crazy yards and sizes those merchants up there have are a regular Chinese puzzle to us folks. I would rather pay more money and know what I am going to get." My London experience made me sympathize. Any one who has ever bought land in Texas where they still have the old Spanish measures, leagues and varas, and tried to figure out from the description how much land he really has, must know how he felt. We have spent a lot of money on a Panama Canal, and we are probably the main force in maintaining the Pan-American Union. Both of these things are fine, but we have never received from them half the benefit we should. Before the war we allowed South American trade properly ours to go to Germany just because we alienate ourselves from South America through ignorance of language and custom, but more still through this crazy, irrational, antiquated system of weights and measures which we inherited from Mother England. It does us more harm in South America than our Canal and Union do good. That is the supreme reason why the 1913 imports of Bolivia showed $765,-267 from Germany and only $126,966 from the United States. And unless our system is changed, Germany or some other country with the metric system will pick up that trade after the war just as surely as they had it before.

The duty and opportunity which the United States holds in South America is the supreme reason why we should adopt the

[1] An address delivered at Oklahoma A. & M. College.

metric system at once, as one of the changes brought by the war. The war has completely ruined Germany's South American trade. Our boys in France have given us a free field, but we must enter it sympathetically and with understanding and should not allow our commerce to be hobbled by our present system of weights and measures.

There is but one valid reason against the adoption of the metric system and that is the same one that worked its defeat by one vote at the time of the adoption of our decimal money system, back at the time when our Government was founded, and that is, we are lazy. If we adopted it, we would have to learn it. Our mental inertia resists the change. We are so human. The whole universe, mental and physical, resists the new. Whenever a new movement is initiated, whether it be electrical, social, chemical, political or simply the cut of a dress or the hang of a skirt, it encounters opposition. All the stand-patters rise up and pitch bricks at it. It is this inertia that maintains the equilibrium of the world, prevents electrical perpetual motion, and it is a fine thing if not allowed to "stiddy" us so much that we cannot move at all. That is the danger now. Yes, we should all have to learn it. To be sure the schools, in most States under legal compulsion, have been teaching the metric system for years, and most of us at one time or other have been able to say:

"Ten millimeters one centimeter
Ten centimeters one decimeter
Ten decimeters one meter."

with just about as much intelligence as though it were a prayer in Sanskrit. No system of weights and measures can really be learned out of a book any more than a language can. The only way to learn it is to live with it, learn it by contact. Of course the idea that we now know the "English system" is pure myth. How many cubic inches in a quart? "58.75," responds the knowing one. "Correct," says the teacher. "Which quart is this, wet or dry measure? Will you please answer?" Don't all speak at once. An extensive canvass has shown that not five per cent of the people have even a fair knowledge of our present system of weights and measures. Don't you remember how this denominate numbers stuff just drove you mad when you studied arithmetic in school?

The metric system was produced at the time of the French Revolution by the best scientists in France. It took long and careful expert work to perfect it. It was so flawless when first

submitted and adopted that there have never been any changes in it since and it has been exclusively adopted by the entire scientific world and practically all the civilized countries of the globe and by a lot of them that would have to hustle to get into that category. But our present system that holds us down like a millstone about our necks, like Topsy "just growed." It is without rhyme or reason. The foot was at first supposed to be the length of the foot of Hercules. Later it was the king's foot. A new king a new foot. The inch was the length between the first and second joints of the mid-finger of the king's right hand. The yard was the length of the king's right arm. They, too, changed with the monarch. Finally King James, of Biblical fame, got his arm, foot and joint length established by action of Parliament as the final and official English measures. John, that king whose name England has never repeated lest it revive unpleasant memories, one day cut a staff or "rood" out of the swamp and used it to measure things and established it as the official rod. It happened not to be a multiple of his foot length, but that was small matter. It has stuck. Think of the mental strain, paper and pencil he could have saved the world by cutting that old stick off so as to make the rod an even fifteen feet. Kings, kings, kings! A fine sort of way for a republic to get its weights and measures! The metric system—and remember it is really a SYSTEM—was born of the blood of the French Republic! The parts of our crazy quilt, which we call a system by exquisite courtesy, fit each other just as we might expect the parts of a thing to fit, each one of which was made by a different person, no one in particular, and just sort of grew up out of the dark, piece by piece, through the centuries. Whenever we say mile or bushel or quart or pound or anything else in our system we must, if we would be exact inquire, "Which one?" The names are never explicit. In a wholesale drug house in Boston we used Troy, apothecary, avoirdupois and metric all side by side. Sage bought by the hundred, avoirdupois, was sold by the ounce, apothecary. The prescriptions divided honors between apothecary and metric systems almost equally. They called it a drug house, and the mathematical combinations we had to work were enough to drive you to drugs. Some system! Our fathers used it and they are all dead. We were raised on it, and will have none other.

Germany has the metric system, but she had to fight to get it. If there are any individuals more set in their ways than the old

German dyers, I have not yet met them. They learned their rule-of-thumb processes from others of their kind, and used a thermometer called the Reaumur, which had zero for freezing, and eighty for boiling water. Now the Centigrade thermometer is a part and parcel of the metric system and Germany has taxed the production of Reaumur thermometers ever since the adoption of the Centigrade and yet many Reaumurs are still used in spite of the tax of over three dollars each. I suppose we should have the same sort of difficulty with our Fahrenheit thermometer which is crazier, if possible, than the Reaumur. An old German by the name of Fahrenheit living in England knowing that powdered ice and salt got very cold foolishly thought it was the lowest obtainable temperature, or "ultimate zero," and so fixed the zero on his scale at this point. What a shock it would have been if he had known the temperature of solid helium, 389.4 degrees below his "ultimate zero," and still at least some ten degrees above absolute zero. How he got his 212 degrees for boiling water he died without revealing.

Still a lot of folks will try nothing and hold fast to the old—valiant champions of a dying cause—just as thousands of farmers the past summer refused to change their clocks because they knew they were right, and I suppose since the twenty-seventh of October are glorying in the fact that the country by coming back to their time has vindicated their position, just as Passe Partout in Verne's "Tour of the World in Eighty Days," refused to change his watch as he toured around the world, and was delirious with joy when he got back home and found his watch was still right. Germany never has been able to get rid of the Pfund and Zenter, but she worked a clever ruse. She changed slightly the value of the Pfund and made it equal 500 metric grams, and it does little harm to let the word stick, so long as it is half a kilogram. We could do the same thing, if it would make the change any easier. 2.2 pounds avoirdupois equal a kilogram, and 2,200 pounds a metric ton.

The word "pound" could be retained if it were increased one-tenth in value, then its value would be half a kilogram. Likewise the meter might also be called a yard. There are 39.37 inches in a meter, so the change would not be great. Of course the decimal subdivisions would have to entirely displace the inch and the foot, as its decimal character is one of the outstanding advantages of the metric system.

Contrast the ease of figuring the English and American money.

How much is a four mill tax on $10,000? How much is a "ha' pence" tax on 2,000 pounds? There is even a greater difference in the English and metric weights and measures. The one consists in multiplying or dividing by 12, 16½, 231, 1,728, and other such classics; the other in sliding the decimal point to right or left.

The metric system could be thoroughly learned in the schools in one-tenth the time the children now put on the present system which they do not begin to master. Educators have argued learnedly and long for the adoption of the metric system, if for this reason alone. The teaching of arithmetic could be shortened by a fifth. Nothing can be said to add to the many excellent articles already written on this subject. The United States and Great Britain have long considered themselves the leaders of the world, and yet we are the only two nations claiming to be civilized according to Western standards who do not have the metric system. We send missionaries to Borneo, Siam, Madagascar and South America, but they all have the metric system.

Our present weights and measures wholly lack any correlation of the several parts, a thing so perfect in the metric system. Take for example the weight, dimensional and volume relations in these two analogous problems. A can holds four and a half pounds of water, what is the volume in quarts? The solution is obtained from the following figures:

$$\frac{4.5}{62.5} \times \frac{1728}{58.75} = \text{Answer.}$$

In order to obtain these you are forced to remember that a cubic foot of water weighs 62.5 pounds, that there are 1,728 cubic inches in a cubic foot and 58.75 cubic inches in a quart. How would a South American get on in solving such a problem? In the metric system the corresponding problem has no mathematics at all, for the weight in kilograms is the volume in liters. The fact that a cubic meter of water weighs a metric tonne; a liter, a kilogram; and a cubic centimeter, a gram, gives at once the volume and weight of any vessel of water if its dimensions are known; or its cubical dimensions if the weight is known. If the liquid is any other than water, simple multiplication by its specific gravity, gives the same results. Such a system as ours offers a mighty commercial handicap in dealing with any nation save Great Britain, which it takes a lot of other excellencies to overcome. This is especially important in the case of the South

American nations where the average education is not so high. And they are precisely the people of greatest commercial importance to us, especially now. It is bad business to be queer, when your queerness causes your customers a lot of distasteful work which they avoid by trading with your competitors. Even in the interstate relations and commerce we suffer. These bushels and things are not determined by congressional action, but each State has its own peculiar sort, and they are far from uniform in the several States. A bushel of salt in Kentucky is by no means a bushel in Pennsylvania. Between the United States and British weights and measures there are even greater differences. All sorts of things constitute a pound, but a kilogram is forever the same the world over. The bushel may vary, but the liter never does.

"Yes, I know," said a farmer to me, "but think of all the millions of dollars that would be wasted in making this change. Why, every scale in the United States would have to be thrown away." Strangely enough that seems to be the popular impression. It is utterly false. Simply the weights and the graduation plate on the beam would need to be changed. The expense would be trifling. It would be met by the saving in lead pencils alone in five years.

The metric system has always been the standard in the United States. A yard has always been officially defined as a certain fraction of a meter, the pound as a fraction of a kilogram. A long, forward step was taken a short while ago when the government bureaus decided that all weights and measures in government bulletins should be given in metric measures as well as in the old system. This was a great satisfaction to the scientific men of the country who have never used anything other than the metric system and Centigrade thermometer. Again and again the pharmaceutical associations of the country have resolved to urge that all prescriptions and formulas be given in metric measures. Its universal adoption is rapidly coming. The United States Pharmacopeia has long been in the metric system. Most intelligent people now have at least a working knowledge of the system, and thousands of our people know it very much better than they do the English system.

The present seems preeminently the time when this change in our system of weights and measures should be made. Our export trade has in time past been sadly handicapped by the lack of a merchant marine. Statesmen and business organizations

have threatened, pleaded and prayed for an American merchant marine, particularly because of our South American relations, but all in vain. Now the holocaust of war has given us as a by-product the greatest merchant marine in all the world, and the wonder of it is that it is government owned. The colossal development of our foreign trade should be an outstanding feature of the after-the-war reconstruction days. Surely we should not insanely cling to an obsolete system that will hold us back from the things we could otherwise do. Now our soldier boys are coming home and "over there" they have learned the metric system more or less thoroughly and have also acquired a great love and admiration for the things of the land of Lafayette. Our patriotism and hope for American commerce, our love for France and her system and our own sane business judgment all combine in urging the adoption of the metric system at this time.

The common argument against the change at this time is that things are in enough of a state of turmoil without adding a sweeping innovation to make matters worse. "Better wait until things settle down a bit." This psychology is in error. People are creatures of habit. The best time to sell liberty bonds is when people are in the habit of buying them. Each succeeding issue has sold better than the former. The best time to get donations for the Red Cross and other forms of war work is when the people are in the habit of giving to such things. The inertia that prevents change becomes momentum when changes are once started. This fact gives rise to the excesses of revolutionists. The psychologically correct time to make such a change as the one we advocate is when people are already educated to changes. It was at such a time that France introduced the metric system. And surely we are more accustomed to changes now than we ever were. Never have so many radical innovations been packed into so short a time. Almost within a year the government has taken over the control of the railroads, telegraph, telephone, essential industries, priority control of nearly everything from building materials to freight shipments, has entered upon an elaborate system of price fixing, has arbitrarily shifted the time of the nation forward and back, has brought about the consolidation of all American express companies, has controlled the national fuel distribution and production and most remarkable of all has even dictated what and how much we might eat. The wildest socialistic dreams have never equalled the actual achievements of the time. Folks are a lot like animals, they object to having anyone

disturb their food. They will stand nearly anything else better. Hoover essayed the impossible when he attempted food administration in America. The change to the metric system would be nothing compared to that. The wonder is he actually put it across. Its accomplishment was possible solely because it was put on a voluntary patriotic basis. Hoover led instead of drove. It will long be one of the wonders of governmental administration in a republic. The fact that these things have been done and people are now educated in the possibilities of united patriotic action, makes the present most auspicious for the adoption of the metric system.

Its adoption is a great patriotic duty. The change cannot be made in a day. It will take time to get the system working, but some date should be set at which it will go into compulsory effect. If all things going into interstate and export commerce, both commodities and catalogs, were forced to be in the metric system as well as all government rulings, publications and the like and all states urged to adopt similar laws governing their state affairs, the change to the new system could be accomplished in a short time, especially so if its use were made a patriotic measure, as it really is. Any one using the old system would soon be tabooed, as is the use of the German language all over the country now.

Germany adopted the metric system in the face of great opposition because it was recommended by the scientists of that country. If a vote were taken of all the people in the United States who have expert knowledge of the subject, the vote would favor the immediate change to the metric system by a majority of at least 99 to 1. The argument of one man who favors the metric system because he has used both systems and knows them well, ought to outweigh the opposition of many whose only ground for objection is that they know nothing about the new system. German science and industry have surpassed that of the United States only in the perfection of their organization. Germany adopted the metric system because of the commercial advantage it would give her. Is American mental laziness to be our worst enemy in South America while Germany is allowed once more to reap a commercial harvest from the fields we neglect?

The adoption of the metric system is coming. A few uninformed senators may be able to delay its arrival but they cannot change the final outcome. Everything points to the present as the supremely advantageous hour to make the move. Economy, science and commerce all demand it. If eventually, why not now?

THE LABORATORY MANUAL—ITS PURPOSE AND CONTENTS.

I.

By Herbert Brownell,
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The laboratory manual of this discussion, like "the child" of whom so much is heard in gatherings of teachers, is a creature of the imagination. Nevertheless, it is quite possible to so narrow a discussion of it, and to so characterize it, as to warrant an expectation that in some not distant time it may materialize for the use of science teachers in secondary schools.

In the publication of books for school uses, even as in the manufacture of ready-made clothing, "the trade" demands certain standards as result of business experiences. Any adjustment of a manual to the particular needs of a class, or school, or instructor corresponds in some degree to the "alterations" necessary in a ready-made suit when fitted to an individual customer. Misfits in either case entail grief and disheartenment. On the other hand it is a bold and rather venturesome thing to wholly break away from established customs whether in clothes or in laboratory manuals.

However, in the evolution of manuals for secondary school sciences, innovations such as are named in this discussion are but further advances in a changing conception of laboratory administration quite notable in the last few years, and believed to have much of promise of yet better things to come.

The type of manual long familiar to us has been a rather inexpensive book of directions for working experiments. These directions are often models of clearness and brevity, though utterly lacking, it may be, in any appeal to the pupils either through so-called "problems" presented as laboratory exercises, or in the results obtained by the pupils. It is, of course, the teaching supposition that these experiences of the laboratory furnish material for constructive thinking, both in the laboratory and later in the classroom. They may justly be considered the most dependable means for correctly interpreting the instruction given in textbooks. A normal curiosity as to "what is going to happen" in these experimental exercises, and of the ways of bringing it all about, is relied upon to sustain a working interest in them. Oftentimes these manuals are made more attractive, and their directions more definite and concise, by the use of wisely chosen cuts and diagrams. In some manuals various "tables" and other

data are appended, furnishing valuable information as well as material for use by both pupil and teacher.

But admirable as are many of the published manuals whose contents are thus characterized, their use often leaves something to be desired from them—something apparently not attainable through their use. There is in them that which is perfunctory—a mechanical routine which often is disappointing in its results. Just what this lack may be is not at all times apparent even when due allowance has been made for teaching conditions, and for any indifference on the part of the pupils under instruction. In spite of all endeavors to have it otherwise, as viewed by the pupils the work of the laboratory is merely incidental to that of the classroom, a sideshow to the main performance, And pupils who painstakingly complete the "laboratory courses" commonly fail of acquiring either the scientific spirit, or the characteristic procedure of scientific effort, in a solution of life's problems. When due allowance has been made for teaching inefficiency—and there are not lacking many evidences of it in the public schools—there still exists a suspicion amounting to a belief in the minds of teachers of secondary school science, and of close observers of the products of these science courses, that the laboratory manual of largest educational worth is yet to materialize.

II.

In his visions of what in general shall be characteristics of this best-of-all manuals, certain outstanding features have gradually taken shape with the writer:

In the first place any such manual must lend itself to a conception of the laboratory hour *as a study period*. During this laboratory time, and under guidance of the instructor, there becomes possible a methodical and sustained training of pupils day by day in ways of acquiring knowledge which are characteristically scientific.

In the second place, before any experiments are worked by the pupils, it must provide that whatever knowledge they may have of the topic under consideration shall be assembled through questioning, and organized about the results of a certain small amount of experimental work *done by the teacher*. Obviously, these experiments must be simple, and so chosen that a scientific understanding of both the old and the newly acquired knowledge results. These experiments should be such as to arouse and sustain interest, provoke thought, and become centers in

the new groupings of knowledge. Whether this discussion shall require one period or two, and whether completed for any topic the same day or not, is of less importance than the question of what teaching values are attained. To hurry the presentation of scientific fact and theory upon pupils mentally unprepared to receive it, and indifferent to it because unprepared, is to defeat the end which prompted the haste. To the author of a manual in any field of secondary school science necessarily must be left the form of presentation of material whereby to attain these several teaching aims at the hands of teachers using the book. A sufficient number of suitable experiments for such use by the instructor may be suggested rather than given in detail in the manual. The question list, too, can be a mere skeleton, suggesting a progressive thought activity in the attainment of certain well-defined ends. A more comprehensive list is likely to invite mechanical rather than spontaneous class thinking.

It is both the province and the opportunity of the instructor during this time of introductory discussion to guide it in such ways and to so enrich its content that it becomes a teaching period of largest possibilities. Certain common experiences in the lives of the pupils may safely be assumed, together with their possession of more or less knowledge of a general character. All this is likely to be of utmost worth in attempts to understand life phenomena. To interpret simply and effectively these many unrelated experiences of pupils, the instructor must be prepared to contribute much additional information to the end that what is known by the pupils, both old and new knowledge, shall have scientific organization and significance. Then each succeeding phase in the discussion of any particular "problem" acquires its correct bearings and scientific relationships.

In connection with these introductory discussions certain carefully chosen page-and-page references will provide not only a setting and due perspective for every discussion, but furnish flexibility to the course. These reference readings may be op tional, and limited in use to the more rapid workers of the class In making choice of such references the general and the popular, rather than the scientific and the exact, are likely to make the desired appeal to the interests of high-school pupils.

During the "write-up" *in the laboratory* following the exercises which the pupils have worked out, there is little serious objection to the use of texts and other reference books by the pupils *as need arises to satisfy a desire for more definite knowledge and fuller in-*

formation. In fact there is great educational gain in thus stimulating and establishing an attitude in pupils which discerns clearly just what they need to know, and directs them in the ways of acquiring this desired knowledge *at the time when it is most serviceable.* This is a training for life which "carries over" from school days into any and all the varied activities of later years. A combined use of books and experimental exercises as sources of knowledge is far more productive in science teaching than any separate and unrelated use.

Then in this manual of the future the writer would incorporate the experimental exercises for pupils found in current manuals, constituting as these commonly do admirable choices for the several fields of secondary school science. Optional experiments of a quantitative character, as part of the laboratory exercises provided for use by pupils, are perhaps one of the happiest solutions of a need to adjust laboratory requirements to the varying capabilities of pupils in a class. With a minimum of required work for all, provision must ever be made that pupils more keen and ambitious shall neither be denied doing all of which they are capable, nor lack the stimulus for doing it.

Following each of these sets of experiments the writer would have lists of Questions for Thought and Reference as "Exercises," their number varying with the topic and designed to serve several ends. Some of them may be review questions concerned with what has presumably been under discussion in the introduction to the topic, or in the experiments worked by pupils. Other questions may well anticipate difficulties to be experienced later in the text assignments, necessitating a discriminating use of the text and of other books in seeking information of a specific character. Such requirements lessen the time required later by pupils to prepare for a "quiz" upon text matter, some of its more extended discussions being thus disposed of. Others of these exercises may be quantitative in character, anticipating and paving the way for those of a more difficult nature which as problems and quantitative experiments properly constitute the laboratory work *of an applied type* following mastery of the text assignments. There may be topical or theme requirements either with or without outlines. These may very properly include industrial as well as scientific phases of the subject, and should be optional.

Somewhere, probably in an Appendix, there certainly should be preserved the tabulated data and other important information

now found in many manuals. Directions to pupils, suggestions to teachers, and such other helps as directions for making chemical reagent solutions, biological cultures, etc., etc., serve to make the manual a working tool for the most effective laboratory service.

Conceptions of this character concerning laboratory manuals are an invasion upon the time-honored functions of a "text." Such a manual is something more than a set of experimental exercises. Insofar as there is a simple experimental basis for it, the manual may fittingly and assuredly appropriate to its introductory discussions parts of the theory of the science. There is little likelihood of any failure in such teaching procedure to leave for subsequent text discussions sufficient difficulties to tax fully both teacher and pupils.

Manifestly every pupil must have a manual for individual use. It is his guide in the primary and fundamental stages of his studies. The number of texts needed is a question of how many duplicate copies are required for reference purposes, and in preparations for a quiz. Upon textbooks teachers must ever be largely dependent for an orderly presentation of the facts of the subject studied, and for a carefully digested and well-balanced presentation of theory too commonly lacking in classroom presentation.

That various and sundry objections may be raised to this conception of a manual is taken for granted. It is likely that it will be a more expensive book than the manuals we have now. It may be advisable to have its pages as large at least as the "history paper" in common use in schools. It is not impossible that publishers might be induced to put it upon the market unbound when desired, with the possibility of ordering the separate exercises as selected in lots of one hundred or less. Matters of publication such as these are not insuperable difficulties. The ideal is a book which in the hands of science teachers of secondary schools generally will yield, in the several science courses, not only a better mastery of the science subject matter in far larger degree than now, but as well provide in its more comprehensive laboratory studies a training whose normal product is a student body *who have a desire to know, who have learned how to study, and who have become habituated to those ways of acquiring knowledge and mastering "problems" suitably characterized as scientific.*

THE VALUE OF LABORATORY NOTEBOOKS.

By Percy E. Rowell,

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There is one value in the written work of the laboratory that is often overlooked or forgotten. This lies in the opportunity of organized self-expression. Unless some definite change takes place in the mind of the student, something which is to produce a lasting impression, then the laboratory work has been of little use. The experiment which the pupil performs has for its object the development of an idea; it is not so much the study of a thing as a study of what the thing represents. It should never be a matter of real investigation, for that belongs to the advanced scientific work. The investigator merely jots down the data which he has obtained; the student should write up his notes, if he is to obtain the full value of the laboratory method of learning.

Rather than discussing the troubles which seem to be inseparable from the laboratory notebook, it may not be out of place to explain the plan which has met with considerable success. The pupil, before he begins the experiment heads his paper with his name, the date, and the number and title of the experiment. Then, as soon as he performs any part of the experiment he writes all that he can perceive by means of his senses—and he writes nothing else. These parts are numbered according to the paragraphing in the manual. Thus at the time he finishes his experiment he has nothing to write except the last paragraph. He now has his scientific data, but no reasons, no calculations, and no answers to questions except data questions. That night part of his home lessons is to write up his experiment. In this is the chief educational value, for he must consult his references, think out the causes, and draw conclusions which are based upon both the text and his data. The finished experiment is handed to the instructor the next day, and it is read while the pupil looks on. The time necessary for this is considerable at the beginning of the course, but rapidly decreases, as the pupils become accustomed to the scientific method of procedure, until about two minutes is sufficient for each experiment. This method gives the teacher an opportunity of individual instruction, and he can discover at an early stage of the work any lack of understanding on the part of any pupil. He can also determine whether he has been offering the course in the best and most efficient manner.

As an illustration of the above the following is offered:

To Prepare and Experiment With Oxygen.

Part I. *Data.*

1. I prepared apparatus, as shown in the *drawing*, and gently heated the mixture of potassium chlorate and manganese dioxide. I collected five bottles of the gas by the downward displacement of water.
2. In one bottle I thrust the glowing end of a splinter of wood. It burst into flame and burned vigorously. I added a few drops of calcium hydroxide to the bottle, covered with my hand, and shook. The liquid turned white.
3. In another bottle I burned a little sulphur on a combustion spoon. (sketch). It burned with a bright blue flame and white fumes were produced. I added a little water and a piece of blue litmus paper. Soon the paper turned pink.
4. (And so on to the end.)

Part II. *Exposition.*

1. The gas was oxygen and it came from the potassium chlorate ($KC10_3$). The manganese dioxide (MnO_2) was added to cause the oxygen to come off evenly and at a lower temperature than it would from $KC10_3$ alone. $2KC10_3 \rightarrow 2KC1 + 30_2$. This is an example of decomposition.
2. When wood is burned in oxygen carbon dioxide (CO_2) is formed. Calcium hydroxide ($Ca(OH)_2$) is a test for CO_2. $CO_2 + Ca(OH) \rightarrow CaCO_3 + H_2O$.
3. When sulphur is burned in oxygen two substances are formed. A gas, sulphur dioxide (SO_2) and a solid, sulphur trioxide (SO_3). SO_3 forms the white fumes. So_2 and water form sulphurous acid (H_2SO_3); SO_3 and water form sulphuric acid (H_2SO_4). $H_2O + SO_2 \rightarrow H_2SO_3$.
4. (And so on to the end.)

Problems, if any.
Questions, if any.

Such a piece of written work is very valuable. First, it has compelled the pupil to attend strictly to business in obtaining his data without having his attention divided by being compelled to write out causes and reasons, answers and problems.

Secondly, he has studied his work for the purpose of supplying a need—the true basis of real education. Finally, and of the greatest value to the pupil, he has found it necessary to think connectedly to a final conclusion. The actual written work, on the piece of paper, may be of some value as preparatory work for an examination, or as a review, but the true value has been reached when it was finished. It is a means to an end and not an end in itself. Therefore it should not be graded, since it is on a par with the daily *preparation* for a lesson.

Now it can be seen that the loose-leaf notebooks, in which it becomes the duty of the pupil to fill in blanks, are only time-savers and take away from the laboratory work much of its inherent educational value. Administrative difficulties must not be confused with educational difficulties.

Sectional drawings should be required in all experiments where the apparatus is new or complicated. Again, drawing should be considered as a means of expression, just as are writing and talk-

ing. The value lies in the ability which is acquired to express the idea, rather than in the attempt to impress the particular apparatus on the mind of the pupil.

If the time ever comes when we shall get away from the science notebook because the interest of the pupil is so great that he does his work, and knows what he does, then also will recitations become unnecessary, and the teacher's work will be devoted to lectures! If considered as a means to an end, the science notebook is the greatest educational factor in the learning process of a science; if considered as an end in itself it is one of the greatest farces of modern education, and is productive of much educational hypocrisy. As a tool it is priceless, as a product it is worthless.

PROVING A GEOMETRICAL FALLACY BY TRIGONOMETRY[1].

By William W. Johnson,
Cleveland, Ohio.

The following gives an exact proof for the exercise given in Sander's *Elements of Plane & Solid Geometry*, page 150, exercise 489, which is:

"A piece of cardboard 8 inches square is cut into four pieces, 1, 2, 3, and 4, as shown in the first figure. These pieces, as placed in the second figure, apparently form a rectangle whose area is 65 square inches. Explain the fallacy by means of similar triangles."

In Fig. 2, if $y+z=90°$, then,

$$\tan(y+z) = \frac{\tan y+\tan z}{1-\tan y\tan z} = \tan 90° = \infty.$$

Therefore, $1-\tan y\tan z = 0$, or $\tan y\tan z = 1$.

But, $\tan y = {}^3/_8$, and $\tan z = {}^5/_2$,

therefore, $\tan y\tan z = {}^3/_8 \text{x} {}^5/_2 = {}^{15}/_{16}$, which is less than 1. Therefore, $y+z < 90°$, and $y+z+x = 90°$, in which angle x is to be determined.

In Fig. 2 ABCD is a parallelogram, AD being parallel to CB and AC parallel to DB, with CE perpendicular to DB. Hence its area = DBxCE. To find CE, we must find the angle EBC = x, which equals the difference between the sum of the angles DBF and CBG and 90°.

$$\tan(x+y+z) = \frac{\tan x+\tan y+\tan z-\tan x\tan y\tan z}{1-\tan x\tan y-\tan x\tan z-\tan y\tan z}$$

Since, $x+y+z = 90°$, then $\tan(x+y+z) = \infty$,

and the denominator of the above relation becomes zero, or

[1] John Phin, *The Seven Follies of Science*, pp. 126-7.

$\tan x \tan y + \tan x \tan z + \tan y \tan z = 1.$ (A)
From the right triangles, BDF and BCG, we find $\tan y = 3/8$, and $\tan z = 5/2$.
Substituting these values in (A), we find $\tan x = 1/46$. Length of $CB = \sqrt{2^2+5^2} = \sqrt{29}$, and $CE = CB \times \sin x$.

$$\text{Since } \tan x = 1/46,\ \sin x = \frac{\tan x}{\sqrt{1+\tan^2 x}} = \frac{1}{\sqrt{2117}}$$

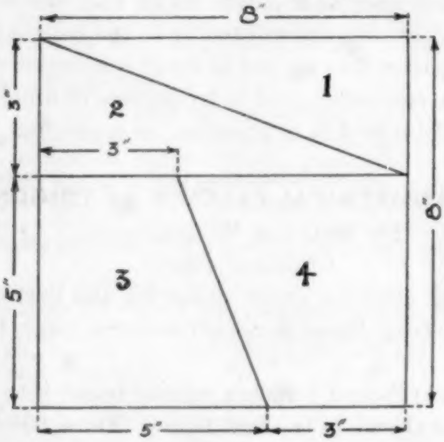


Fig. 1.

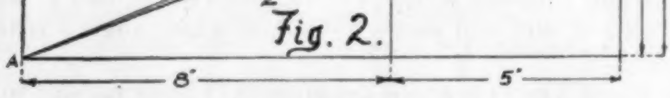


Fig. 2.

Then, $CE = \sqrt{29} \times \frac{1}{\sqrt{2117}} = \frac{1}{\sqrt{73}}$, and $DB = \sqrt{3^2+8^2} = \sqrt{73}$.
Therefore the area of parallelogram $ADBC = DB \times CE =$

$\sqrt{73} \times 1 = \frac{1}{\sqrt{73}} = 1$ square inch.

The above gives an exact proof that the area of the cardboard in either figure is the same; 64 square inches. The apparent possibility of this problem lies in the fact that angle x is a very small angle, i. e., $1° 14' 43.31''$.

BOYLE'S LAW AND THE ADIABATIC EFFECT.

By John C. Shedd,
Occidental College, Los Angeles, Cal.

If in the usual form of experiment for the verification of Boyle's Law we let

B = Barometric Pressure
V_o = Vol. of the gas at Pressure B
h = Difference of level of the H_g column in the two tubes.

Then $P = B + h$

$$VP = B.V_o \qquad (1)$$

This is the equation of the equilateral hyperbola and its plat is usually made the object of the experiment.

This is a useful form of experiment but every instructor using it recognizes the fact that the graph is a poor criterion of the value of the data. An extra column showing the product of P·V is generally added for this purpose. Sometimes a progression variation in the value of P·V may be observed which is evidence of the adiabatic heating or cooling of the gas.

Data of such an experiment is shown in Table I and plotted in Curve I.

Table I.

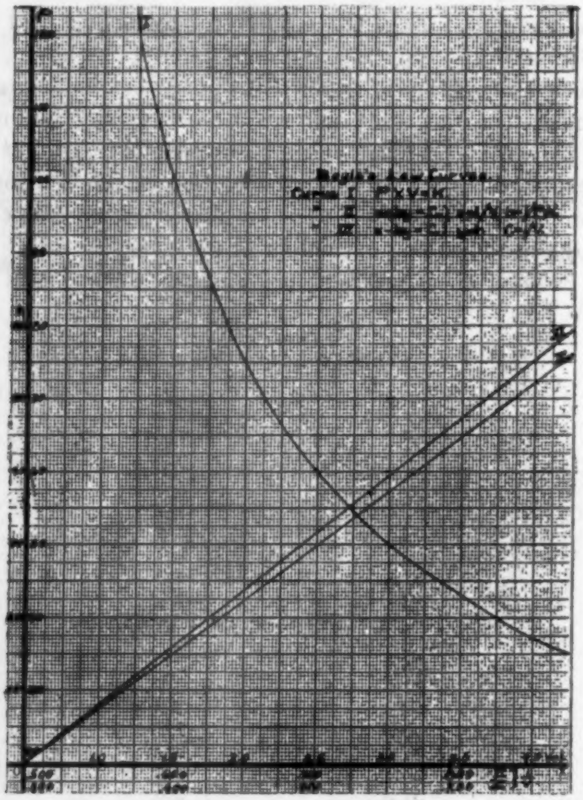
(A) Pressures greater than one atmosphere.

h	$P = B + h$	V	P×V
0	75.1	2	150.2
4	79.1	1.9	150.0
8.4	83.4	1.8	150.0
13.8	88.9	1.7	151.0
19.	94.1	1.6	151.0
25.3	100.4	1.5	150.1
33.1	108.2	1.4	151.6
41.1	116.2	1.3	151.0
52.7	127.8	1.2	153.4
63.1	138.2	1.1	152.1

(B) Pressures less than one atmosphere.

h	$P = B - h$	V	P×V
0	75.1	2	150.2
3.6	71.5	2.1	150.2
6.8	68.3	2.2	150.3
9.6	65.5	2.3	150.4
12.5	62.6	2.4	150.4
15.0	60.1	2.5	150.4
17.2	57.9	2.6	150.6
18.2	55.9	2.7	150.8
21.3	53.8	2.8	150.1
23.2	51.9	2.9	150.4
24.9	50.2	3.0	150.6
28.1	47.0	3.2	150.4
30.7	44.4	3.4	150.9
33.2	41.9	3.6	150.8
35.4	39.7	3.8	150.8
37.4	37.7	4.0	150.7
39.2	35.9	4.2	150.7
41.	34.1	4.4	150.3
42.5	32.6	4.6	149.8
43.8	31.3	4.8	150.0
44.8	30.3	5.	151.6

An inspection of Table I and Curve I shows a typical example of the experiment. Two or three of the data show evidence of being poorly taken while no evidence worth mentioning of the adiabatic effect can be seen; unless a rise of .4 per cent in the product P×V for pressures under one atmosphere be regarded as such. Here however, it is seen that the departure is in the wrong direction i. e., the cooling effect here present should have caused a lowering in the product P×V, not an increase.



It is now proposed to show how this data can be handled so as to furnish a clear criterion of the value of the data and also show the adiabatic heating and cooling present. It is suggested that this work forms a very suitable second experiment under Boyle's law preferably taking new data for the purpose.

Equation (1) may readily be put into the form

$$x \pm by = c \qquad (2)$$

This is done by letting

$$x = 1/V, y = h, b = 1/BV_0, C = 1/V_0$$

Since equation (2) is that of a straight line its plat is a ready test of the value of the data—poor data falling off the line. The slope of the lines then are two—is

$$dy/dx = \pm b = \pm 1/\mathrm{BV}. \qquad (3)$$

A lack of agreement in the slope of the two lines may be taken as due to the adiabatic effect. In this we may expect the slope for PB to be greater in the experimental data than for PB. It may also be noted that in the plat the variables are 1/V and h; hence B does not enter into the plat thus avoiding one source of error.

As seen in equation (3) the lines should in the plat have equal and opposite slopes according as

$$\mathrm{P} > \mathrm{B} \text{ or}$$
$$\mathrm{P} < \mathrm{B}$$

If in platting equation (2) both lines be placed in the first quadrant, and if the data has been carefully taken, it may be found that the two lines do not quite coincide, the line for P > B lying a little above that for P < B.

The reason for this lies in the adiabatic heating or cooling of the gas as the experiment progresses. If it be desired to bring out this effect the experiment should be performed as rapidly as accuracy in taking readings will permit. If it be desired to avoid it, i. e. to verify Boyle's Law as perfectly as possible, time for the equalization of temperature should be allowed between each reading.

The following data and plat will illustrate the above. The data is that of Table I and was taken in the course of an ordinary experiment.

TABLE II.

V	$x = 1/\mathrm{V}$	$y = h$
5.0	.200	44.8
4.8	.208	43.8
4.6	.217	42.5
4.4	.227	41.0
4.2	.238	39.2
4.0	.250	37.4
3.8	.256	35.4
3.6	.278	33.2
3.4	.294	30.7
3.2	.313	28.1
3.0	.333	24.9
2.9	.345	23.2
2.8	.351	21.3
2.7	.370	19.2
2.6	.385	17.2
2.5	.400	15.0
2.4	.417	12.5
2.3	.435	9.6

2.2	.455	6.8
2.1	.476	3.6
2.0	.500	4.0
1.9	.526	4.0
1.8	.556	8.4
1.7	.588	13.8
1.6	.625	19.0
1.5	.667	25.3
1.4	.714	33.1
1.3	.770	41.1
1.2	.832	52.7
1.1	.909	63.1

This data is platted in Curves II and III where it will be seen that a few of the points fall off the lines. It will also be seen that the slopes of the two lines is not the same.

It would be interesting to follow further the *adiabatic effect* as here shown and to inquire into the possibility of using it as an experiment for the determination of the mechanical equivalent of heat. That, however must await another paper.

SOCIALIZING THE STUDY OF ELECTRICITY AS A PART OF THE HIGH SCHOOL COURSE IN PHYSICS.

By Marshall Coots,

High School, Mansfield, Mo.

Among the subjects offered in our modern high school courses, that of physics, if we except the commercial work, seems to lend itself most readily to socialization. This is true in a yet fuller extent, if we limit our discussion to the smaller schools which offer limited courses.

Breaking up the subject of physics into its larger divisions, i. e., mechanics, heat, electricity, sound, and light, it is a difficult thing to select one particular phase of the subject as better than the others for the object of this paper. The study of electricity proves most interesting and inviting to the writer, if the word "inviting" may be used, although to many others who have taught the subject this may be a poor selection. Perhaps the following part of this paper will justify the selection.

To the average boy or girl, the word electricity means something vague and elusive, and yet something about which each thinks he or she knows quite a little. This slight knowledge of natural phenomena, such as the lightning, thunder, and the practical applications of electricity to trolley cars and electric lights, etc., serves as a basis for the motive and interest which must exist if the pupils are to receive much benefit from their study. Thus at the beginning of their course, the attention is caught and held. Experiments are performed gladly and eagerly in order

to test out certain laws and facts. Searches are made in practical kinds of work outside of school in order to find out just how certain principles work out when used commercially. The better students have a desire to carry over into the actual life of the community their school life, and this rounds out their education as it could not be done in any other way.

The size and resources of the town will determine to quite an extent the thoroughness with which our work can be accomplished. In a country village the socializing of this branch of science is extremely difficult, but in a modern city, or even in a town of fair size, many opportunities present themselves. The ability and energy of the teacher are necessary factors in providing opportunities for the pupils to make visits to certain places where they are not likely to be welcome.

This immediately brings up the question of how to obtain the proper attitude of those in practical life toward the school. To a large degree this state of affairs depends upon the interest that is felt for the school. Usually ideal relations do not spring into existence spontaneously, but are the growth of untiring work on the part of school officials and teachers, together with the aid of certain high-minded individuals who live in the community and who have been interested in and worked for this community spirit. In every school district there are or have been some men who are bitterly opposed to a better school, and some who are indifferent. These men, if they are in the majority, have to be educated to a realization of their duty to society, and this task should be led and worked out under the guidance of the superintendent, aided by directors, teachers, and all liberal minded citizens.

Every teacher should feel the desire to interest those outside the school in his particular work, as well as in the school as a unit. The physics teacher should take advantage of the chances offered to obtain help from, and to interest the telephone man, those who operate the power plant of the town, the local station agent, owners of garages, hardware dealers, and even the jeweler. These points may be passed now, as they will be discussed later.

The adaptability of our subject to socialization also depends upon the provisions the school authorities have made for the proper teaching of the subject. The best results cannot be obtained unless efficient laboratory and demonstration equipment has been provided. This means that the apparatus should have been selected with care, and good rooms and desks and

tables provided. Adequate reference books, selected to cover the field thoroughly and intended for high school pupils are also a necessity for thorough work. The most important selection is the teacher, who must not only know the theoretical and the practical phases of his subject, but also know how to present all phases in the best manner possible. Unless a good teacher is provided, the board has failed in one of its duties, along with the failure of the superintendent.

By the time the subject of electricity is reached, the teacher should have searched out the various resources of the community in this particular field. Even while the subject is being studied, he should constantly be on the lookout for any opportunity that offers to aid him in his work. If a new need is felt he should exert himself to find the aid needed.

While searching for these practical helps, the teacher should form new and valuable friendships. Here is the time to display a good personality, and to make the people admire him because of his desire to be friendly and the interest he shows in their work. Not all people are good mixers, but anybody can be more or less successful in forming friends if he but tries, and is sincere in his efforts. Every teacher should feel that it is his duty to help develop the proper community spirit, but not for his personal good alone.

Perhaps before the study of the resources of the community, but not necessarily, the teacher should have checked over carefully the equipment of the laboratories of the school, in order to know just how it may be supplemented from outside sources. Certain articles may be needed to facilitate the carrying out of particular experiments, or to serve as part of the demonstration apparatus. Tools, household utensils, and different models of the ordinary shocking machine may be obtained in this way. The electric vacuum-cleaner may be studied in the home of some member of the class where it is installed. Such articles as electric irons, flashlights, and heaters or cookers might also be brought in by members of the class for study.

From local hardware stores, repair shops, and garages, such things as voltmeters, ammeters, storage batteries, dry batteries, and small motors can be obtained for an hour or so for study, or to relieve the pressure when the school equipment is insufficient to meet the demands made upon it at that time. Some of these men may be able to tell the students how storage batteries are charged, and also show the process. A jeweler may

explain how a watch may become magnetized, why it will not keep accurate time, and how it can be demagnetized. He may then show the actual process.

The local telephone company will usually be willing to supply old transmitters, receivers, and telephones for the asking or at a small cost. If the manager is friendly toward the school, he may be able to explain to a few of the members of the class the principles of the switchboard, the overhead cable system, or the underground system.

It should be mentioned at this point, that all borrowed equipment ought to be returned promptly and in good condition. If an article is borrowed for half an hour, it should be returned at the end of that time. Unless the school is considerate of the time and interests of the business man, he will not be willing to inconvenience himself for the school.

The local power plant offers a number of opportunities for practical study. This is a place where the entire class may be taken, and such problems as the making of electricity, the source of power, the dynamo, and electrical wiring, may be studied. The single or three phase circuit is best understood when explained where the system is actually working. The automatic switchboard, its uses and advantages are also best explained before the actual switchboard. Such visits may be made to factories, manufacturing establishments, etc., and other principles studied. The real value and use of the electro-magnet may be made strikingly clear, if the student sees one lift several tons of iron when the operator simply throws a small switch, and release the iron when the current is broken. It is not always possible to make use of all the advantages mentioned, but at least a part of them is always available.

Sometimes those in charge of the shops or plants will gladly explain machinery and processes, and when they will, the teacher should welcome the service. In case there is no one to do this, the teacher should make use of such knowledge as he has, but should not overemphasize or state for facts what he does not know for sure. Sometimes during the following recitation period time may be taken for a discussion of the things observed while on the visit, and the teacher explain or correct points of interest or errors.

Constant illustrations of a concrete nature should be given in the class work, by the pupils when they know them, and then by the teacher. In this manner the practical and the theoretical

are best correlated, and the best results obtained. Concrete examples are not difficult to find if one gives a little thought to the matter, and they are of infinite value.

In conclusion let us sum up the results of our attempt to socialize this branch of a subject as it should be taught in a modern high school, enumerating those who will profit, by individuals and by groups.

Firstly, the teacher profits, inasmuch as he gains an insight into the lives of his pupils and the people of the community that he could not gain in any other way. In this manner he has a chance to live within the things that are directly concerned with their existence, and thus he gains a position unattainable by almost any other means. Secondly, the pupils learn how to observe life more accurately, and are brought to think seriously about the work they are to follow later as a life calling. Better methods of study are inculcated, and a spirit of brotherhood is formed between the students themselves, and between the students and the men whose industries and businesses they have been studying. Thirdly, the school officials get a better grasp of the students, their interests, and their good will, and also come to stand for more in the minds of the people in life, who become convinced that the school is doing something. Fourthly, the parents of the students look with favor upon a practical training, and are thus influenced by the interest shown by their children, and the position of the school, to keep their children in school if it is possible. Fifthly, the school gains prestige, and proves more inviting to new students, as well as holds those who are entered in it, and gains in numbers as well as in strength. The idea that it is simply a place to spend time and money on, vanishes. Sixthly, the community profits by receiving young men and women who are better fitted to take up its work. People usually inquire about the school facilities of a town before moving there permanently, and a good school will get good citizens. The community is under obligations to supply an opportunity to its young people for an education, and after this opportunity has been supplied those for whom it has been done owe it to the community to try to become worthy men and women. Thus, lastly, we come to the benefits society derives from the proper training of youth.

A SWITCHBOARD FOR ELECTRICAL TESTING.

By W. H. Farr,
Central Scientific Company, Chicago, Ill.

As the switchboard in use in the testing laboratory of the Central Scientific Company possesses some rather novel features, it was thought that a description of its arrangement and operation might be of interest to the readers of this magazine.

The testing laboratory of a scientific laboratory supply company is called on to make a large variety of tests, no small part of which are electrical. This fact is illustrated by the following representative list selected from the work done in this department during the last year.

Testing the operation, efficiency, and wattage of electrically heated and controlled drying ovens, incubators, water baths and thermostats.

Calibrating voltmeters up to 250 volts and ammeters up to twenty-five amperes.

Calibrating electrostatic voltmeters up to 30,000 volts by the use of high tension transformers.

Charging storage batteries.

Testing or operating lamps, induction coils, and A. C. or D. C. motors of various voltages.

Checking the resistance and current capacity of laboratory rheostats.

Checking the wattage and efficiency of heaters and heating elements.

Locating faults in the wiring of various electrical appliances.

Measuring the carrying capacity of resistance wires, coils, and fuses under special conditions.

Testing X-Ray, cathode ray, and other vacuum tubes.

Operating wireless and high frequency transformers.

For some time after coming to the Central Scientific Company the writer used portable meters and makeshift arrangements of rheostats and lamp banks in testing work. These improvisions were not without their value, for it was through this experience that the writer was able to determine the nature of the tests which the laboratory would be expected to make and what requirements the testing equipment would have to meet when the time should come to design it.

In the summer of 1916 the Central Scientific Company moved to its present commodious quarters on the Lake Shore Drive. This move made it possible for the laboratory to occupy a much

larger space than before, and provided an opportunity for the installation of some permanent electrical testing equipment. This equipment included a testing switchboard, a motor generator, and a distributing system.

The switchboard comprises two panels of heavy slate, each 34 by 36 inches, mounted side by side, one carrying the A. C. equipment and the other the D. C. equipment. These are mounted on substantial angle iron supports extending up to the ceiling, and located at a sufficient distance from the wall to permit easy access to the back of the board for changing fuses. In front of the board at standard bench height is mounted a hardwood shelf 16 inches wide running the full length of the board. This shelf makes it possible to do most of the lighter testing work right at the board.

As the building is located in the direct current district of Chicago, the power supply is a three wire 110-220 volt system. Alternating current is supplied by a motor generator. Two

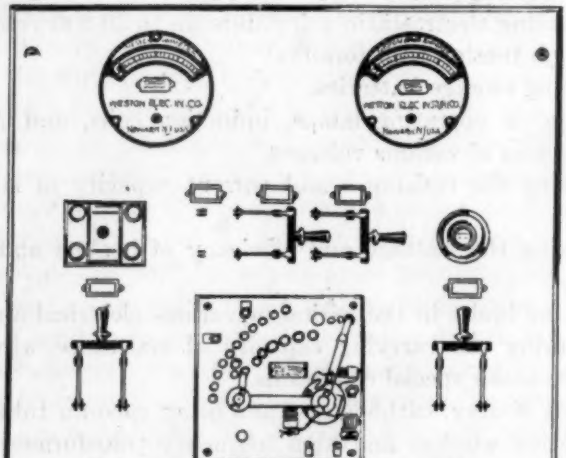


FIGURE 1

advantages of this arrangement are that most of the testing work can be done with direct current, and that the generating of the alternating current in the laboratory gives a wide range of voltages and frequencies which would not otherwise be available.

The motor generator was built for this laboratory by the General Electric Company, and is of the double end two bearing type. The generator is a 1½ K. W. three phase, four-pole machine, giving 110 volts at normal speed. The motor is 2¼ H. P., 220 volt, compound wound, and is controlled by a combined starting box and speed controller, by means of which the speed may be varied between 900 and 2,700 R. P. M. This range of speed gives the generator a frequency of from 30 to 90 cycles, which is sufficient to meet all the requirements of this laboratory. The generator field is supplied from the 220 volt D. C. line, being controlled by a rheostat of comparatively high resistance, making it possible to vary the voltage through a range of over 30 per cent at any given motor speed. This variable speed feature of the motor also extends the voltage range, the extreme limits being about 40 volts at 30 cycles and 180 volts at 90 cycles. By means of appropriate transformers, any desired voltage can be obtained at any given frequency.

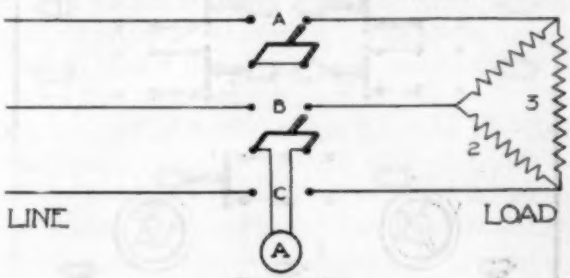


FIGURE 2

On the alternating current panel (see Figure 1) are mounted the starting and control box for the motor generator, the field rheostat, a 125 volt A. C. voltmeter, a 10 ampere A. C. ammeter, the control switches for the motor and generator, and three sets of terminals for the alternating current. The voltmeter is connected through a standard three phase voltmeter plug, by means of which it may be instantly thrown across any one of three phases. The ammeter is connected through a special switch which may be described as a double pole triple throw, having two pairs of blades and three pairs of clips, so arranged that either pair of blades can be thrown into the center pair of clips. As indicated in the wiring diagram in Figure 2, the ammeter is connected across the blades of one switch, while the blades of the other are short circuited. The switches are closed in the positions A, B, for phase 1, B, C, for phase 2, and

A, C, for phase 3. Thus either phase may be used separately, and the ammeter is always in circuit. For three-phase work the ammeter may be placed in whichever phase is desired, the third contact being closed with a removable clip.

On the direct current panel (see Figure 3), are mounted a 250 volt D. C. voltmeter, a 25 ampere D. C. ammeter, two rheostats, six switches, and the necessary terminals. A is the main switch, and serves to disconnect the whole D. C. panel. The switch D is thrown to the left for 110 volts and to the right for 220 volts. B, C, and E are for obtaining various combinations of the rheostats, their use being described below.

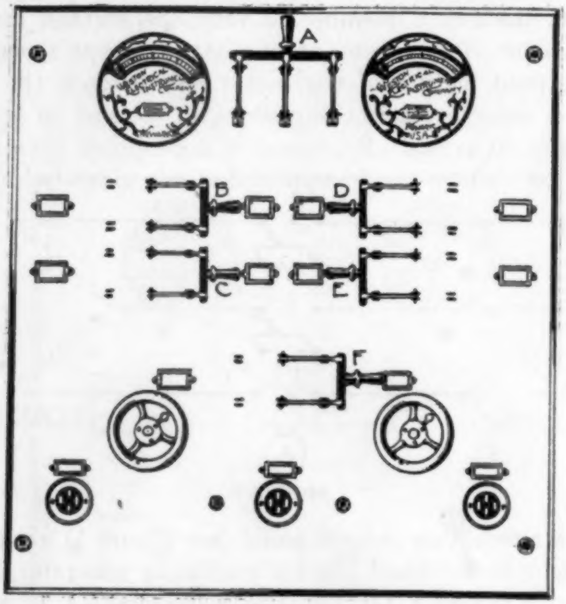


FIGURE 3

F reverses the polarity of the working terminals. Two field rheostats of the three plate type are used, each having a maximum resistance of 40 ohms and a maximum current capacity of 12.5 amperes. As each rheostat has about 65 steps, it is possible to secure sufficiently fine adjustments of voltage or current for calibrating meters. The connections of the rheostats are controlled by two switches, B and C, the wiring of which is shown in Figure 4. When B and C are both thrown to the right, which is equivalent to closing switch 2 in Figure 4, the rheostats are in series with each other. When B and C are thrown to the left, which is equivalent to closing 1 and 3,

they are in parallel. Either rheostat may also be used singly by throwing the corresponding switch to the left, i e., closing 1 or 3, leaving the other one open. It is thus possible to obtain a maximum resistance of 80 ohms (with the rheostats in series), and a maximum current capacity through the rheostats of 25 amperes (with the rheostats in parallel).

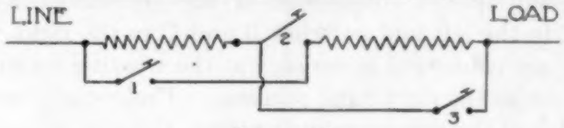


FIGURE 4

The D. C. voltmeter is so connected that it measures the P. D. across the working terminals rather than the line voltage. These values are not the same when some of the resistance of the rheostats is in series with the load. The ammeter is also connected so as to read the current flowing in the working circuit, which may not always be the same as the current drawn from the line, as for example when the potentiometer connection described below is being used. The above arrangement of the meters facilitates measurement of resistance or wattage of rheostats, heating units, motors, etc.

Another type of work for which this board is well fitted is tracing out connections or locating short or open circuits in electrical appliances. To do this the two rheostats are connected in series with each other, and in series with the working terminals, providing sufficient protective resistance to prevent any injury to the meters or fuses. In fact, with all the resistance in circuit, less than one and one-half amperes will be drawn from the line in case of a short circuit. The testing terminals are then applied to various points of the wiring in the appliance under test, and the readings of the voltmeter and ammeter noted. In case of a short circuit or a connection having a very low resistance, the voltmeter will read practically zero, while the ammeter will indicate a flow of current. In case of an open circuit, the voltmeter will read the full line voltage, but the ammeter will read zero. In case the circuit is normal, i. e., includes more or less resistance, the readings of the meters will give an index to the amount of such resistance. The above arrangement replaces the old-fashioned test lamp, whose use was practically limited to determining whether or not a circuit was complete. The brightness of such a lamp gives at best a rather hazy idea of the amount of resistance in the circuit.

In certain kinds of low voltage work it is not practical to reduce the line voltage by means of series resistance, as for example when operating or testing battery motors, lamps, or coils. A bank of storage cells of sufficient size to provide a wide range of voltages is expensive, and requires no little attention. Provision has been made for this type of work by arranging a potentiometer connection of the rheostats. Throwing switch E to the left and switches B and C to the right, the two rheostats are connected in series, but the working terminals are shunted across the right hand rheostat. Under these conditions a reduction of the resistance in the latter rheostat will reduce by a corresponding amount the P. D. across the working terminals, and vice versa. Also a reduction of the resistance in the left hand rheostat will increase this P. D. By proper manipulations any voltage between zero and 220 may be obtained.

As will be noted in Figure 3, there are three receptacles at the bottom of the D. C. panel. The middle one of these is the working circuit, being connected through the switches, meters and rheostats. The right hand receptacle is connected directly to the 110 volt line and the left hand one to the 220 volt line. This arrangement makes it possible to use at the same time three different voltages. On both the A. C. and D. C. panels binding posts are provided to which connections may be made when it is not convenient to use the receptacles.

In connection with the switchboard a simple but efficient distributing system is used. Beneath the testing shelf is mounted a gang of six receptacles like those used on the board. From these receptacles circuits are carried to the dark room, the show room, and the various benches in the laboratory. Connections are made by means of flexible cords having a two finger type of plug on each end. It is thus possible to have instantly available at any part of the laboratory whatever current or voltage is desired.

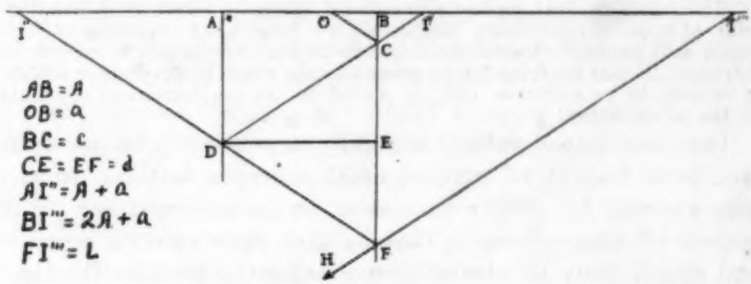
LENGTH OF PATH OF LIGHT TRAVELED BY REFLECTION FROM MIRRORS.

By James S. Stevens,
University of Maine, Orono.

In Preston's *Light* we have given a problem which requires us to prove that when light from an object is viewed by an eye after successive reflections from two mirrors, the actual path traveled by the light is equal to the apparent distance of the last image to the eye.

A figure like the one below proves the proposition graphically; for it is easily seen from the laws of light that $FI^{111} = OCDF$. If the eye is placed at H the line HF is common to the two paths and may be neglected.

The following is a mathematical method of proving the same thing:



$L = \sqrt{(2A+a)^2 + (c+2d)^2}$

$OC = \sqrt{a^2+c^2}$

$CD = \sqrt{A^2+d^2}$

$OCDF = \sqrt{a^2+c^2} + 2\sqrt{A^2+d^2}$

We are to prove $L = OCDF$.

Equate the values:

$\sqrt{(2A+a)^2+(c+2d)^2} = \sqrt{a^2+c^2} + 2\sqrt{A^2+d^2}.$

Square both sides:

$(2A+a)^2 + (c+2d)^2 = a^2+c^2+4\sqrt{(a^2+c^2)\ (A^2+d^2)} + 4A^2+4d^2.$

Expand:

$4A^2+4Aa+a^2+c^2+4cd+4d^2 = a^2+c^2+4\sqrt{(a^2+c^2)\ (A^2+d^2)} +$
$4A^2+4d^2.$

Cancel:

$Aa+cd = \sqrt{(a^2+c^2)\ (A^2+d^2)}.$

Square:

$A^2a^2+2Aacd+c^2d^2 = (a^2+c^2)\ (A^2+d^2) = A^2a^2+a^2d^2+c^2d^2+c^2A^2$

Cancel:

$2Aacd = a^2d^2+c^2A^2.$

By similar triangles:

$A : d :: a : c.$

$Ac = ad.$

Substituting:

$2a^2d^2 = 2a^2d^2.$

The two equations are equal and the lines FI^{111} and OCDF are equal.

CONCERNING PSYCHOLOGIC TESTS IN THE ARMY AND THEIR MEANING FOR THE TEACHER.

By J. W. A. Young,
The University of Chicago.

In recent years the assertion has frequently been heard that mental training and mental abilities are "specific," not "general."

"This discipline trains—not general faculties but specialized abilities."[1]

"The following standard of educational values is based upon the doctrine of specific disciplines, supported, we believe, by experimental evidence and general observation. Mathematics, for instance, would be defended on this doctrine for its great specific value in developing ability to reason, to be accurate, etc., in regard to the mathematical elements in the environment."[2]

That one may develop his ability to reason, to be accurate, etc., with respect to mathematical concepts, without in any wise altering his ability to reason, to be accurate, etc., with respect to other concepts, that is, that there exists a separate and closed body of mental processes for the work in the large and varied aggregate that our schoolrooms label "mathematics" and which processes function nowhere else, is a supposition which needs only to be stated to exhibit its absurdity.

When one seeks definite grounds for assertions of the above type, the advocates of specific values are very chary with specific reasons. One meets with "general" assertions that "psychologists have established" this or that, that belief in the functioning of the results of mental training beyond the specific content of the training material is now "discredited," in fact, so thoroughly "exploded" as to be discreditable, but specific proofs or even references thereto are difficult to find.

As a matter of fact, a large body of psychologic experiment of dominating import, is based on just the opposite assumption, namely the assumption that mental abilities are not restricted in their functioning to content of a specific verbal label, but are of a wide, general range; for example, that the degree of speed and accuracy with which a soldier will comprehend and execute commands on the battlefield will correspond to the degree of speed and accuracy with which he comprehends and executes the direction to draw lines about circles in the testing room.

A most striking instance is found in the tests devised for the U. S. Government by a commission of eminent psychologists and applied to a million and a half men in the army. The tests have recently been made public.[3]

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[1]Flexner, A., Education as a Mental Discipline, Atlantic Monthly, April, 1917, p. 458.
[2]Heck, W. H., Mental Discipline and Educational Values, 1912, pp. 163, 162.
[3]For instance, in a pamphlet, "Army Mental Tests," printed at Washington, November 22, 1918, and now distributed by the Division of Psychology, in an authorised interview published in the New York Times, February 16, 1919, and in a traveling exhibit which was shown in the North-Western University Building, Chicago, Feb. 11-14. The statements below are drawn from these sources.

The tests aimed at determining the man's general mental power and not his specific attainments. Those in charge believed that they achieved this aim.

"The rating a man earns furnishes a fairly reliable index of his ability to learn, to think quickly and accurately, to analyze a situation, to maintain a state of mental alertness, and to comprehend and follow instructions."

The degrees of intelligence were graded as follows:

A. Very superior intelligence. Men of high officer type (when endowed with leadership, etc.).

B. Superior intelligence. Many men of officer type, and a large amount of non-commissioned officer material.

C+. High average intelligence.

C. Average intelligence.

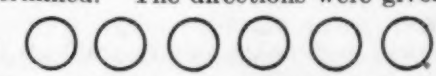
C−. Low average intelligence.

D. Inferior intelligence.

D−. Very inferior intelligence but fit for regular service.

E. Very inferior intelligence and not fit for regular service.

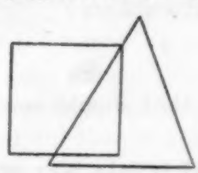
The following are samples of the tests by which these grades were determined. The directions were given orally.

Given: 

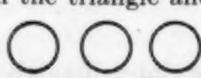
Directions: Make a cross in the second circle and also a figure 1 in the third circle. (Time allowed, five seconds.)

Given: 

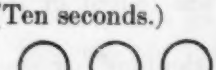
Directions: Draw a line from circle 2 to circle 5 that will pass above circle 3 and below circle 4.

Given: 

Directions: Make a cross in the space which is in the square and not in the triangle, and also make a figure in the space which is in the triangle and not in the square. (Ten seconds.)

Given:  YES NO.

Directions: If a regiment is bigger than a company, then put a cross in the first circle. If not, draw a line under the word "No." (Ten seconds.)

Given:  MILITARY GUN CAMP.

Directions: Make in the first circle, the last letter of the first word; in the second circle, the last letter of the second word, and in the third circle, the third letter of the third word. (Ten seconds.)

Given: **34-79-56-87-68-25-82-47-27-31-64-93-71-41-52-99.**

Directions: Cross out each number that is more than 30 but less than 40. (Fifteen seconds.)

Given: **1-2-3-4-5-6-7-8-9.**

Directions: If 6 is more than 4 then cross out the number 5, unless 5 is more than 7, in which case draw a line under the number 6. (Ten seconds.)

Given: Twenty questions in mental arithmetic, of which the first and last are:

1. How many are forty and six guns?

20. A commission house, which had already supplied 1,897 barrels of apples to a cantonment, delivered the remainder of the stock to 28 mess halls. Of this remainder, each mess hall received 47 barrels. What was the total number of barrels supplied?

(Five minutes allowed to solve the twenty problems.)

Given: If plants are dying for lack of rain you should
Water them.
Ask a florist's advice.
Put fertilizer around them.

Directions: Make a cross before the best answer.

(One and one-half minutes allowed to mark sixteen sentences like the above each with three printed answers.)

Given: 5 10 15 20 25 30 ....
21 18 16 15 12 10 ....

Directions: Write the two numbers that should come next in each row.

Given: Order-confusion peace **part treaty war enemy.**

Directions: Notice the relation between the first two words, and then underline the word in heavy type that is related to the third word in the same way.

Similarly:

Education-ignorance wealth **poverty riches health comfort.**
10-100 1,000 **money 10,000 20,000 wealth.**

Given: The battle of Lexington was fought in 1620, 1775, 1812, 1864.

Directions: Underline that one of the four last words which makes the truest sentence.

Similarly: The kilowatt is used in measuring rainfall, windpower, electricity, waterpower.

An eight-sided figure is called a trapezium, scholium, parallelogram, octagon.

How familiar these questions sound to the teacher of mathematics! How akin in substance and in spirit to certain phases of his subject! But they are the phases of which he is least proud; which, indeed, he probably regards as a necessary evil, the scaffolding without which he cannot build his edifice. If any high schools and colleges had said in recent years: "We will forget the valuable content of mathematics, second in widespread usefulness only to the mother tongue, we will make no effort to exhibit to our students its clear cut logic—the model and ideal of all sciences—we will concentrate all our energies on training our students to speed and accuracy in its most rudimentary processes," what a chorus of protest would have arisen! "Useless," "artificial," "mere puzzles," "unrelated to real life," "trains only the most restricted special abilities," would have been heard from all sides. Yet the student from such a school, when called to the army, would have been rewarded by a higher rating in *general intelligence,* for whatever skill he had acquired through this training. For we are told in no uncertain terms, that the objects of these most specific tests was to measure the most general abilities. Thus it is stated by the Division of Psychology that:

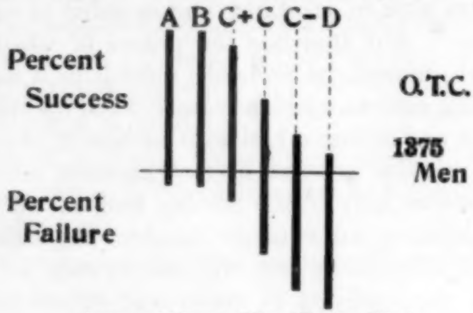
"These tests provide an immediate and reasonably dependable classification of the men according to general intelligence. Their specific purposes are to aid in the discovery of men whose superior intelligence suggests their consideration for advancement, in forming organizations of uniform mental strength, where such uniformity is desirable, in forming organizations of superior mental strength where such superiority is demanded, in the early recognition of the mentally slow, etc."

The psychologic ratings were given at the outset, and their correctness was promptly put to the test in the work that followed in the military training schools. The verdict was throughout highly gratifying and distinctly confirmed the ratings. The diagrams on page 548 will serve sufficiently as specimens of many such corroboratory outcomes:

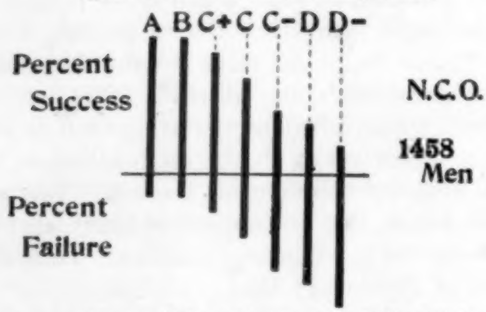
So satisfactory have the results of these psychologic tests been that Columbia University has announced its purpose of using such tests in passing upon applications for admission to the university, and that strong efforts are being made to extend these methods to business organizations.

What does all this mean for the teacher of arithmetic, of high school mathematics? Does it mean that much more stress

should be laid on the most elementary formalism, on extensive and intensive drill in the type of work that psychologists use to test men's general intelligence? Our information as to the nature of the tests and their outcomes is still too fragmentary to furnish definitive answers to these questions.



Success and failure in Officers' Training Schools.



Success and failure in Non-commissioned Officers' Training Schools

One thing, however, is already evident. No teacher of mathematics who believes that the study of his subject can contribute to the advancement of the pupil's general intelligence and who teaches with such advancement as one of his aims, need be disquieted by any assertions that psychology is against him. Even though he may see no whit of improvement in the pupil's mathematical thinking, or in his ability to handle the subject's more complicated processes, or in his appreciation of its wide range of usefulness, if the teacher succeeds only in giving the pupil such increased familiarity with the most elementary notions of the subject as will enable him with greater speed and accuracy to mark a cross in the square and not in the triangle, and to draw a line from the second circle above the third and below the fourth to the fifth, he may rest content with the knowledge that the best psychologists that the United States Government could summon to its aid will, in consequence of that improvement, rate that pupil higher in *general intelligence*.

NOTES ON BIOLOGY TEACHING.

By Benjamin C. Gruenberg,
Julia Richman High School, New York City.

VIII. Discussion of Oxidation in Candle Flame.

Good plan to have the subject of discussion concretely present to the senses—the lit candle in view of all. But it should be more than present. You had several occasions to point directly to the candle, or to have it do something, that you did not use—e. g., when the pupil had doubt as to whether the fluid at the base of the wick was water. It is not a question of accepting the teacher's authority; we have to receive a very large part of our mental stores on authority. It is a question of constantly demonstrating the method by which authority obtains validity. *We know because we experience, not because we are told.*

We have frequent occasions to call for deductive thinking in the form of classification—e. g., what kind of change is this, what kind of blood flows in the veins, etc. In such cases you must be sure that the categories and the criteria are in the minds of the pupil; otherwise the question is wasted, and you have to follow up with the general questions—what are the different kinds of changes (or blood); how do we distinguish them, etc.

Direct questions carry their answers with them; it is practically impossible to avoid this in the tone of voice unless you purposefully try to puzzle the pupil. "Does this experiment alone show so and so?" "Do we burn the food for the sake of the CO_2?" "Did we see this ourselves?" and so on.

Why not ask, in the case of the basis for the pupils' certainty regarding water-vapor emitted by flame: "How do you know that the flame gives off water-vapor?" Put the responsibility for the form of expression as well as for the thought upon the pupil. It is too easy to say *Yes* and *No.*

The use of the experiment has its advantages, but it also has its dangers.

(1) One girl starts to describe an experiment—identified by the most striking features in the way of apparatus or result—by listing materials used. An outsider may properly describe what he saw the people in the room do; but a participant may discuss an experiment primarily only in terms of a *problem!*

(2) One pupil reported an experiment (I think it was the one burning a candle with a limited amount of air in a self-registering space), confusing the results with the conclusions.

One of the things we are aiming at is the consciousness of the process of basing conclusions upon facts, and of keeping generalizations distinct from data.

(3) An experiment was described on the problem (apparently) "Is oxygen necessary to burning?" The performance described consisted of finding out that oxygen does indeed accelerate the process of burning, or that perhaps it facilitates it; but there was nothing to show that oxygen is *nccessary*. There is here a serious fallacy that the pupils can understand. I know they are able to understand it because one of the girls referred to the same fallacy in connection with the procedure for carbon dioxide. Look out for the *Negative Instance.*

To assist discussion of abstractions represented by words or symbols, you should use the blackboard more: e. g., the gases of the air; confusion of hydrogen and nitrogen; carbon and carbon-dioxid.

Look out for the repetition of pupil's answers. Concrete demonstration: you have no doubt demonstrated the relation of smoke to incomplete combustion; but when the question arose again in the course of the discussion, it would have been well to point to the bunsen burner again, to remind those who needed, and in any case to reenforce, and to enrich the association with the problem of smoky gas-burners on the kitchen range at home.

Your questions are not always well considered, and you realize the defects even while you are speaking. It may be worth while to formulate some of the more important questions in advance. The difficulty is usually with questions that have dependent clauses in them. Often you are obliged to introduce dependent clauses because you ask question number two ahead of question number one. That is, you should give some thought to question sequence.

IX. Lesson on Matter.

Although you do not consider the pupils very bright, they do not seem to give you any trouble. They leave you free to concentrate your energy on planning the material you wish to teach them and on thinking out more effective methods of presentation. The order of the room as well as of the pupils was excellent.

I believe that we are in perfect agreement as to whether our teaching is to accomplish any more than the transmission of more or less useful information. You will be on your guard

against lapsing into such cheap substitutes for clear thinking as are represented by phrases like, "Water seeks its own level," "Earthworms love darkness," "Nature hates a vacuum," etc. Let me suggest that you read the chapter, "From Magic to Medicine," in Dr. White's "Warfare of Science."

I can think of only one valid excuse for dictating to children definitions for their own future use, and that is that the teacher's definition is more accurate—and therefore more enduring—than any definition the pupil is likely to build up for himself or than he can readily find in such books as are immediately accessible to him. From this point of view the responsibility falls upon us to formulate definitions that really are capable of standing every reasonable test.

(a) You define *elements* as "substances so simple in their nature that they have not yet been by any known means separated into anything simpler." Accepting the statement at its face value, what is implied by the phrase "by any known means?" It suggested to me that the emphasis is not on the fact of separation, but on the expert's ignorance of the means by which such separations come to be. Have elements yet been separated by means to us unknown? Aside from that phrase, I had not means, of course, of knowing what apperception the pupils brought to the rest of the definition.

(b) The pupils made heroic efforts to recall the definition of *compound;* there was no evidence that any of them were trying to understand what you were talking about. "A compound is a substance composed of two or more elements united together in a new and distinct substance." Distinct from what? From each of the elements? From the mixture? From other compounds? "Very often the compound is absolutely different, a brand new substance." In what sense is a compound a brand new substance? Is it new in the history of the world? Is it new to the person who succeeds in bringing about a chemical union of elements? Are new compounds constantly arising in the normal course of natural processes or of artificial processes?

There is of course much to be said for the teacher formulating the summaries that the pupil is to put into his repository of "notes;" but the teacher's effort must not be altogether a substitute for the pupil's effort. It is only after the students have themselves attempted to organize such information as they have that you are warranted in supplementing from your larger store, and with your more experienced technique.

Let me suggest that you go over your plans for the term with a view to eliminating the topics that do not seem to bring satisfactory results and to elaborating those that seem to be more valuable.

X. Advanced Class in Hygiene.

In addition to teaching such facts and principles as we consider of importance to our pupils in connection with the subject matter, it seems to me that it is part of our business to develop a dynamic attitude toward all thought. It would seem out of the question for us to give any considerable time in our schools to the study of the history of human thought. It is possible, nevertheless, so to present our subject matter as to leave a very distinct by-product in the form of a feeling of historic change. In this connection you will find it particularly dangerous to use the definite article in a way that implies finality. We speak of *the* atomic theory, or of *the* evolution theory, or *the* law of gravity, with perfect safety in a context or in surroundings that leave no room for ambiguity. We cannot, however, thus anchor the pupil's thought in speaking of scientific problems that involve current controversial issues. Thus *the* three laws of heredity can mean anything and everything. It means everything when it suggests that there are precisely three laws—neither more nor less and that these laws are eternal; but since these implications are not in accordance with the facts, it means nothing.

Do you teach "law" as something universal and eternal, or do you teach it as something tentative and expedient? If the former, how do you reconcile it with the fact that the progress of science is constantly repudiating *laws?* If the latter, how do you reconcile it with our faith in the validity of the scientific method? These are not academic questions; they have to do with fundamental attitudes towards the importance of your teaching both as method and as subject matter.

XI. Class in Advanced Biology.

A stranger might think it strange indeed that one should use pickled frogs for the study of the breathing mechanism in vertebrates, when living animals are so readily accessible. No doubt you studied living creatures as well as pickled ones. The chief defect in your question, it seems to me, lies in calling upon the pupils to recall what they saw in a concrete situation, rather than calling upon them to restate some generalization of principle. Knowledge may be impossible without facts; but

facts do not constitute knowledge. Again, it is better to learn through concrete sensual experience than through second hand definitions and descriptions and formulae; but after the sensual experience is assimilated, its recall is likely to be a hindrance rather than a help. This kind of recitation could be performed quite as well after the memorization of a catalog; it does not bear internal evidence of the understanding of processes. To be sure, the structures are to be seen, and known by name, and in their spatial relations, but the dynamic element is lacking.

Now that we are fighting for democracy and the overthrow of thrones, would it not be a good plan to cut out the "kingdoms?" Especially since kingdom implies king, and we know practically nothing of either the identity or functions of the implied kings in the animal, vegetable and mineral "kingdoms."

The notes on hayfever furnish an excellent opportunity for restating or emphasizing the principles of specificity, immunity, susceptibility, and serumology. I wonder how many of the pupils understood why one girl's aunt went to the White Mountains every year? The girl who asked about "after-effects" evidently meant damage or symptoms (and she did not know the difference); but her question was not answered.

Notes on kelp are worth elaborating. The plants are sometimes "very large"—yes, 200 feet long or more. The names of chemicals meant very little; but some of them could be connected with more familiar experiences. The "acetate of lime" results from slaking the fermentation liquors with lime; the fermentation results in the formation of acetic acid. Here is another chance for biology—industrial application of bacteria and yeasts.

This class should furnish you abundant material for enriching the instruction in other classes.

XII. Lesson on Photosynthesis.

Most of the class was interested, a few even enthusiastic. There is evident a distinct, though not large, penumbra of indifference.

Several pupils described what "chlorophyl looks like." It had looked "like bricks," "Uneeda Biscuit," "a lot of little holes," "green little round things," etc. You have evidently an elephant on your hands, who resembles a tree trunk, a snake, a rope, a fan and a wall. All the answers represented something actually seen. The important task before you was to make practically every pupil visualize which of all the impressions was the essen-

tial or significant one. The important part of the picture was "the small round green bodies" inside the cells. My impression was that you failed to do this. I may be mistaken, because I realize that pupils soon learn to discover in the teacher's tone of voice or from her manner and facial expressions, an indication of "the right answer," or "the important point." To me, the repetition of "the right answer" seemed rather casual and weak. The opportunity to use the blackboard for emphasis and for aiding those who can see better than they can hear, was missed. Why not have constantly the key words on the blackboard as the discussion develops?

What does the word "photosynthesis" mean? *Photo* is light; *synthesis* means making of starch or putting together. If it is worth while to introduce etymology—and I think it is—it is also worth while to get it in a way that avoids confusion.

The girl who suggested vaseline for excluding light did not get the full benefit of the blunder. Recitation of pupil and comments of teacher should, of course, be addressed to the whole class, but where a comment is called forth by an error from a particular pupil, that particular pupil should certainly have some attention when the comment is forthcoming.

"Is the sun material or energy?"—meaning, no doubt, the light or heat of the sun.

Does tradescantia produce starch?

Have the pupils get on their feet and stand up before beginning to speak.

XIII. Lesson on Seeds.

You assigned the next lesson as pages so and so, near the end of the period. In general, the lesson should be assigned at the beginning of the period. Only one excuse occurs to me for delaying the assignment until later, and that is a need for developing a problem, or a terminology for the statement of the problem. When the lesson assigned is formal, as in this case, it should certainly come at the beginning. However, I do not think it is wise to state an assignment in the form you used, even where it is necessary to help the pupils locate their material in the book by reference to pages or chapters.

It is well to work out a plan for checking off the distribution of the apparatus to avoid possible loss. Of course, you were not prepared this time to use the apparatus as it came up in the middle of the period. This suggests that preparedness is more than a state of mind.

Several times pupils asked about the word "epicotyl" and each time it was necessary to give the same explanation. It should have been apparent, from two or three times, that there was a general need of instruction on this point and it would have been well to stop your work to place the items on the blackboard.

Most of the pupils were marking strophiole "micropyle." It is evident that girls did not even see a "micropyle;" and if the word has been explained to them, they confused a hole with a hill.

In general, my impression is that you have a much stronger grip on your class than you had last year, and that you have more confidence in yourself. I would suggest that it would be worth while to lay out a few lessons in all details with a view to getting the habit of visualizing the lessons as a whole.

HOW WILL THE WAR AFFECT HIGH SCHOOL SCIENCE?

By Charles E. Dull,

South Side High School, Newark, N. J.

Many teachers are of the opinion that one of the effects of the war will be the promotion of the study of sciences, especially of physics and chemistry. Most people will agree, too, that the war was won by the applications of these sciences, despite the fact that an occasional classically-trained man scoffingly refers to the use of the airplane in dropping bombs as the chief contribution of physics, while the science of chemistry produced mustard gas.

Useful as the sciences were in winning the war, they will be even more necessary during the period of reconstruction. The duties of making the devastated areas in Europe habitable will fall upon the shoulders of the engineers. Rule of thumb methods in the various industries have become obsolete. Experts maintain that the science of electricity is now only a lusty infant. The large plants that have been used to manufacture nitric acid for use in war will be valuable for taking nitrogen from the air to be restored to the soil as plant food. Manufacturers in America appreciate the value of by-products as never before. Hundreds of chemists will be kept busy in finding new uses for products that have been wasted.

Let us inquire whether these new conditions brought about by the war will cause an increase in the number of students

electing sciences in the high school. At present there is a demand for American History as a required subject. in the fourth year, on the ground that patriotism may thus be better taught. In order to make better citizens, there is also a clamor for Community Civics, Economics, and even Sociology.

Many of the Eastern high schools offer a college preparatory course and a general course. The latter does not fit for college. In many cases the college preparatory course is strictly classical, and its requirements are apt to be about as follows: English, 3 or 4 points; mathematics, 2 or 2½; Latin, 4; a second foreign language, 3; history, 1; and science, 1; any other points needed to make the 15 or 16 required for college entrance are elective. Suppose to the 14 or more points now required the State Departments of Education add one year of American History, it is evident that some subjects must go into the discard. Shall it be physics or chemistry, or both? Unless some radical changes are made, does it not appear that despite the part science played in the war and its still greater possibilities in time of peace, the number of students electing these sciences is bound to decrease?

In the Middle West where entrance requirements are very liberal, the problem is likely to be solved with little difficulty. In the Eastern high schools the problem is more serious. Some of the Eastern colleges and universities, led by Harvard, Mt. Holyoke, Smith, Vassar, and Wellesley, still require four years of Latin and three years of a second language in preparation for the course leading to the A. B. degree. Some of them prefer an additional two years of a third foreign language. In the face of such requirements, if science in the high school is to continue its growth or even to maintain its present status, the teachers of science must demand one of two things. We must demand that the election of science be optional with at least a part of the excessive language requirement in the present courses, or we must insist on another college preparatory course, to parallel the present one, in which science subjects will receive proper recognition. The writer believes that few science teachers would be willing to draw the fires from the crucible in which American citizens are being tempered. Furthermore, they would be the last to oppose the introduction of any subject that would promote patriotism or good citizenship. It is true also, that practically every one will agree that all high school students must have at least three years of English and two years of mathematics. If science, then, is to have an equal chance, a

part of the seven years required for the study of foreign language must be eliminated. Does it not seem that nearly fifty per cent of a pupil's time spent in studying foreign language is excessive?

If those who make our courses of study see fit to offer a scientific course that is college preparatory, it should in no way be considered inferior to the classical course. The old idea that the A. B. degree is superior to the B. S. degree is quite obsolete enough to be eradicated. At one time it was doubtless superior, and for a good many years the bright student was advised to take the classical course. He was led to believe that some peculiar mental gift is essential to the mastery of the classics. It is doubtful whether the languages are as difficult to master as the science and mathematics in the scientific course as now given. The writer has no quarrel with the language devotees, but he feels that the future of science promises so much that it must not be crowded out of the high schools. The writer has known of legal cases where the lawyer with all his Latin was seriously handicapped because he did not have a knowledge of physics and chemistry. The old-fashioned doctor spoke glibly of herbs with Latinized names, but his knowledge of chemistry too often began and ended with calomel. The modern school of medicine demands a great deal of chemistry and fewer mistakes are buried under flowery verbiage. As a cultural study, the writer believes that either chemistry or physics is decidedly superior to one year of Cicero or Vergil. The time has come when the civilization of a country is measured by the amount of sulphuric acid it uses, or by the number of kilowatts of electrical energy it consumes.

Since the requirements for the B. S. degree are now as stringent as for the A. B. degree, let us taboo the idea of the latter's superiority that still exists in some localities. Let us insist that the language requirements be cut from seven years, exclusive of English, to such a point that the sciences may have a fair share of the pupil's time. If we emphasize the cultural as well as the practical aspect of physics and chemistry, then the idea that science, simply because it brings the student in touch with everyday affairs, is sordid, vulgar, or commercial, will be utterly stamped out. Then the war, which was won by science, will not have been instrumental in crowding science out of the high school, but it will give it the impetus it rightly deserves.

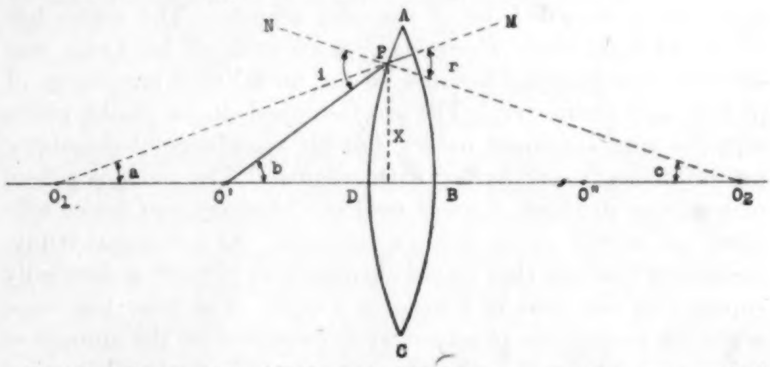
A MODIFICATION OF THE FORMULA FOR THIN LENSES.

By Charles H. Skinner,
Assistant Professor of Physics, Ohio Wesleyan University, Delaware, Ohio.

The relation between the principal focal length, f, the index of refraction, n, and the radii of curvature, R_1 and R_2, of the lens faces of a thin lens is usually expressed by the formula,

$$1/f = (n-1)(1/R_1+1/R_2).$$

Various methods may be followed in determining R_1 and R_2. Perhaps the simplest method for measuring the radii of curvature in the case of double concave lenses is to use each face as a concave mirror, locating the center of curvature as the point where object and image coincide. If the faces of double convex lenses be used as concave mirrors, object and image will not coincide at the centers of curvature but at points which we may call the apparent centers of curvature.



In the figure, let ABC and ADC represent a cross-section of the faces of a double convex lens. Let O_1 be the true center of curvature of ABC, and O′ the apparent center of curvature. In order that a ray leaving O′ and incident at P may return over the same path, it is necessary that its path inside the lens be perpendicular to the face ABC; that is, along the line O_1P produced. Let us call the distance O′B the apparent radius of curvature, R′, of ABC. Also, let O_2 be the true center of curvature of the face ADC, and O″ its apparent center of curvature. Then O″D is its apparent radius of curvature, R″. R_1 and R_2 are the true radii respectively of ABC and ADC.

Let us express the lens formula in terms of the apparent radii of curvature instead of the true radii. Draw the line O_2PN, and consider the ray O′P. Angle O′PN is the angle of incidence, i; and angle O_2PM is the angle of refraction, r. From the figure, it is easily seen that

$$i = \text{angle } PO'D + \text{angle } PO_2D = b+c,$$

and r = angle PO_1D + angle $PO_2D = a+c$.

Now, $n = \sin i/\sin r = \sin(b+c)/\sin(a+c) =$

$$(\sin b\cos c + \cos b\sin c)/(\sin a\cos c + \cos a\sin c).$$

For small angles (and the angles will be small for thin lenses) the cosines in the above expression are approximately equal to unity. Also, $\sin a = X/O_1P = X/R_1$ approximately (see figure),

$\sin b = X/O'P = X/R'$ approximately,

and $\sin c = X/O_2P = X/R_2$ approximately.

Therefore $\sin i = X/R' + X/R_2 = X(1/R' + 1/R_2)$,

$\sin r = X/R_1 + X/R_2 = X(1/R_1 + 1/R_2)$.

Hence,
$$n = (1/R' + 1/R_2)/(1/R_1 + 1/R_2) \qquad (1)$$

By symmetry,
$$n = (1/R'' + 1/R_1)/(1/R_1 + 1/R_2) \qquad (2)$$

Adding equations (1) and (2), and regrouping the numerator of the second member,

$$2n = (1/R' + 1/R'' + 1/R_1 + 1/R_2)/(1/R_1 + 1/R_2)$$
$$= (1/R' + 1/R'')/(1/R_1 + 1/R_2) + 1.$$

Hence, $(1/R_1 + 1/R_2) = (1/R' + 1/R'')/(2n-1)$.

Substituting this in the original lens formula, we have

$$1/f = (n-1)(1/R' + 1/R'')/(2n-1).$$

Thus it is seen that the apparent radii of curvature may be substituted for the real radii of curvature, in the original lens formula, provided the right hand member of the formula be divided by $2n-1$.

If we solve for n from the modified formula, we have

$$n = [f(1/R' + 1/R'') - 1]/[f(1/R' + 1/R'') - 2].$$

To test the above expression for n, a double convex lens was selected and the following data taken, using a spherometer for getting R_1 and R_2. R' and R'' were found as explained above that is, the lens faces were used as concave mirrors, and an illuminated point adjusted till it and its image coincided, thus giving the apparent centers of curvature.

f = 34.5 cm.; R_1 = 32.6 cm.; R_2 = 42.5 cm.; R' = 16.9 cm.; R'' = 19.2 cm.

By original formula, $n = 1.537$,

and by modified formula, $n = 1.540$.

It is often desirable to investigate lenses where the ordinary means of determining the radii of curvature of the faces are not available, or applicable. In such cases, the modified formula will be found useful.

It is interesting to note that in either equation (1) or equation (2) we have a relation whereby the index of refraction may be easily determined without a knowledge of the principal focal length of the lens.

A CLASS EXPERIMENT ON SPHERICAL ABERRATION IN A LENS.

By Frederick A. Osborn,
University of Washington, Seattle.

In reading Tscherning's Physiologic Optics recently the writer noticed for the first time an experimental illustration of spherical aberration, and on trying it, was so delighted that he would like to share his delight with other teachers of physics. As Tscherning's book may not be readily accessible to all teachers a brief description of the experiment is given here.

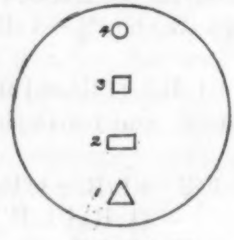


Fig. 1.

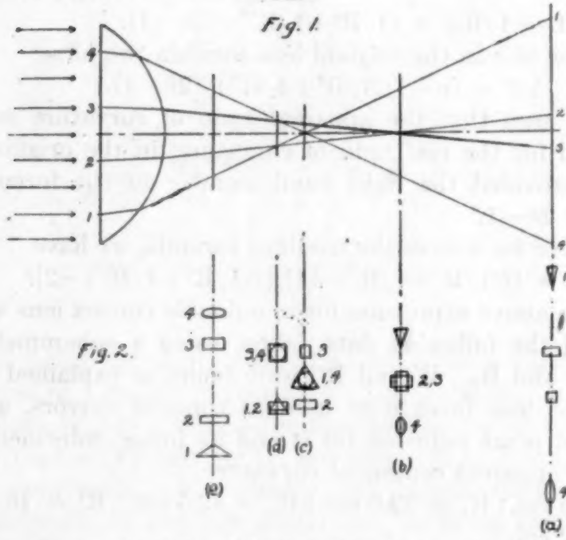


Fig. 2.

The apparatus is all furnished by the lecture lantern. One of the plano-convex condenser lenses is removed and over the plane face is fastened a screen of paper in which four holes equally spaced have been made along the vertical diameter, Fig. 1. The plano side faces a distant luminous source, the lantern giving a slightly diverging beam. A white screen is placed behind the lens to receive the images. For the first case the screen is placed beyond the focus and four images are seen, Fig. 2 (a). The images are in the inverse order and the two

center images 2, 3, are separated by a less distance than are 3, 4 and 1, 2. The two central images are slightly enlarged reproductions of the form of holes 2 and 3, while images 1, 4, are elongated in the vertical plane, the aberration from the edge of the lens being the greater. Moving the screen nearer the lens, the result is shown by (b), the screen is now at the focus for the central portion of the lens, while the edges focus at a shorter distance. By moving the screen still nearer the different phases as shown (c), (d), and (e) may be seen. In the (e) position, notice that the elongation of 1, 4, is now in the horizontal plane.

GEOGRAPHY AT THE PEACE CONFERENCE.

By W. M. Gregory,

Normal School, Cleveland, Ohio.

The world wide discussions raised by the many questions before the Peace Conference in Paris are bringing very forcefully to the people of America the importance of geography in world affairs. The world wide responsibility that this country has assumed demands a wide knowledge of the countries where our credit and trade is extended. Every citizen is using geographical ideas that before the war were unknown. Many countries are looking to our wealth to develop their resources, restore their losses, rebuild their shipping and revive their finances. These activities demand geographical knowledge of the highest type and our educational system must do its duty in training our young people along these lines.

In the final peace terms and in shaping the articles of the League of Nations the geographers of America have a very important place. Special mention should be made of the Inquiry which is an organization authorized by President Wilson to gather facts, prepare maps and collect data for the use of the Peace Conference. The Inquiry commenced its work in 1917 under military guard in the building of the American Geographical Society in New York. When President Wilson sailed for France on December 4, 1918, the entire staff of the Inquiry and the valuable records accompanied the presidential party.

The questions under discussion at the Peace Conference require the latest and most accurate information and maps that can be procured. A large body of geographical facts have been collected and made available for the use of the conference.

Never before has geographical research been so highly regarded and so useful as in the present affairs of the world. Another duty of the geographers connected with the Inquiry has been to prepare a series of maps to visualize questions of territorial boundaries, trade routes, economics, resources, etc. A series of more than sixty maps have been prepared under the supervision of Dr. Isaiah Bowman, Director of the American Geographical Society, Professor Mark Jefferson, Major D. W Johnson, Major Lawrence Martin and other.

The peace negotiations will be greatly benefited by this series of maps that have been made in America. Every pupil in American schools will have an increased interest in these events when they learn of the important part taken by these American geographers at the Peace Conference.

The alert teachers may bring the vital questions of the world war and its settlement before all students by obtaining these maps for a nominal sum from the American Geographical Society of New York. The interest of the world will be centered for a generation upon the large question of the peace settlement and their understanding is based largely upon a knowledge of world geography. This wonderful collection of maps from the American Geographical Society will do much to help the pupils comprehend the present world wide problems.

One of the direct results of the war has been to demonstrate to citizens the meagre character of their school geography. Many schools have been quick to see this weakness and include in their revised curricula more comprehensive courses in geography. The citizen of tomorrow must have a knowledge of world geography, a concept of the great industries, the use of raw materials and the laws of trade and commerce.

Selected List of Books on the Geography of Europe.

General Sources.

Dominian............Frontiers of Language and Nationality in Europe
Gibbon..............New Map of Europe
Fawcett..............Frontiers
Lyde..............Some Frontiers of To-Morrow
Lyde..............The Continent of Europe
Powers..............America Among the Nations
Powers..............The Great Peace
Fairgrieve..............Geography and World Power
Holdich..............Political Frontiers and Boundary Making
Stoddard and Frank..............Stakes of the War
Fleure..............Human Geography in Western Europe

Handbooks.

Finch and Baker..............Geography of World's Agriculture
Davis..............Handbook of Northern France

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler,

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. O. Hassler, 2337 W. 108th Place, Chicago.

Why your proposed problem does not appear.

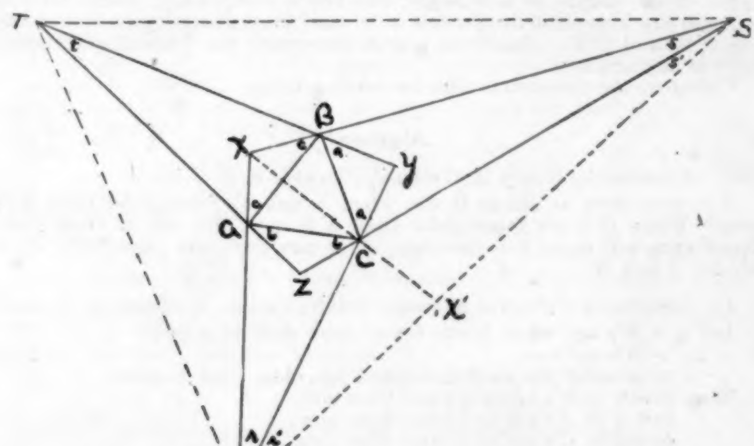
The Editor has on file about 100 proposed problems that have not been used, having received thirty since last issue. This is *not* a request, however, to refrain from sending problems. The more problems we have from which to choose, the better *should* be the list published. Besides, many of the proposed problems have been used, or are more or less common exercises in texts. There is a dearth of applied problems.

SOLUTION OF PROBLEMS.

A Non-trigonometric Solution of 581.

581. *Proposed by A. MacLeod, Aberdeen, Scotland.*

The six straight lines which trisect the angles of a triangle meet in three points which form the vertices of an equilateral triangle.



Solution by U. P. Davis, Alva, Fla.

Draw the equilateral triangle ABC, and the lines YT and YR, through B and C respectively, making the angles a with the line BC, and draw ZT and ZS through A and C respectively, making the angles b with the line AC, a and b being any angles between 0° and 60°, such that $a+b$ is greater than 60° and less than 120°. (If angles YBC and CAZ are together equal to or less than 60°, the lines YT and ZT will not intersect. If $a+b$ is equal to or greater than 120°, angle RCS becomes equal to or greater than 180°.)

Then the angle BTA is greater than 0° and less than 60°. That is, it is equal to one-third of an angle between 0° and 180°.

Draw XS and XR through B and A respectively, making the angle c with AB, where c equals $120° - a - b$, equals angle YCS. Then angle YBS equals b and angle ZAR equals a.

In triangle BCS, $b+a+a+c+s$ equals 180°; or angle s equals $180° - (2a+b+c)$. Then angle r equals $180° - (a+2b+c)$, and t equals $180° - (a+b+2c)$. Combining and substituting, $r+s+t$ equals 60°. Also $s = 60° - a$; angle $r = 60° - b$; and angle $t = 60° - c$. Hence any two of the angles s, r, and t are independent of each other and of every condition except those which must be imposed upon angles which are one-third the angles of a triangle.

Draw SR, ST, and TR making the triangle RST.

In the triangle XRS, angles $X+r+r'+s+s'$ equals 180°. Also $x+2c$ equals 180°. Therefore $r+s+r'+s' = 2c$; but angle ZCR $= c = r'+s'$. Therefore $r+s = r'+s'$.

It is evident that RC and SC bisect the angles XRS and XSR, respectively. For the incenter of triangle XSR must lie upon XX′, bisector of angle RXS. If this incenter is not at C, let any other point C′ be this incenter. Then angles r' and s' will both be increased or both be diminished. But this is impossible if $r+s$ is to remain equal to $r'+s'$.

Therefore RC and SC bisect the angles XRS and XSR, respectively. In the same manner we may prove that RA bisects angle TRC. Then AR and CR are trisectors of the angle TRS.

Likewise TA and TB, SB and SC trisect the angles RTS and TSR, respectively.

Therefore the six trisectors of the triangle RTS meet in three points A, B, and C forming the equilateral triangle ABC. But since any two of the elementary angles r, s, and t, are independent of each other and of every condition except those which must be imposed upon the third parts of the angles of a triangle, the two corresponding angles of the triangle are independent of each other and may assume any values between 0° and 180°. Since two angles determine the form of a triangle, RTS is any triangle.

Therefore the theorem is true for every triangle.

Algebra.

601. *Proposed by Henry R. Hubbard, Plainsfield, N. J.*

A is now twice as old as B was when A was six years older than B is now. When B is six years older than A is now, the sum of their combined ages will equal C's age then. C is now forty-six years old. How old are A and B?

I. *Solution by Catherine Manion, Trinity College, Washington, D. C.*

Let x = B's age when A was 6 yrs. older than B is now.
$2x$ = A's age now.
y = number yrs. until B will be 6 yrs. older than A is now.
Then $2x+6$ = B's age in y years from now.
$2x+y$ = A's age in y years from now.
$46+y$ = C's age in y years from now.

$$2x+6+2x+y = 46+y$$
$$4x = 40$$
$$2x = 20 = \text{A's age now.}$$

Now let w = number years since B was 10.
then $10+w+6$ = A's age when B was 10.
$y = 16$ = number yrs. from time B was 10 until he is 26.

$$10+w+6+y+26 = 46+y-w$$
$$2w = 4$$
$$\therefore w = 2$$

and $10+w = 12$ = B's age now.

Therefore, A is now 20 yrs. old and B is 12.

II. *Solution by John Roberts, Pittsburgh, Pa.*

Let x = A's age now, and y = B's age now.
Then $x-(y+6)$ = the number of years ago that A was six years older than B is now.

Hence $y-(x-y-6)$ = B's age at the time when A was six years older than B is now.

From the first condition

$x/2 = y-(x-y-6)$.

Reducing,

$$3x = 4y+12 \quad (1)$$

Let v = the number of years hence that B will be six years older than A is now.

Therefore

$$y+v = x+6. \quad (2)$$

$$y+v+x+v = 46+v. \quad (3)$$

subtracting (2) from (3),

$$x+v = 40+v-x.$$

$$x = 20 = \text{A's age now.}$$

Substituting this value of x in (1) and reducing, y is found; $y = 12$ = B's age now.

These values of x and y satisfy all conditions of the proposed problem.

Solutions were also received from Gertrude Buck, M. G. Schucker, S. H. Parsons, Laura A. Peck, Tuley, C. P. Lancaster, Fannie Boyce, C. E. Githens, R. A. Rossiter, G. Lamb, Mabel C. McLaughlin, Edward Blankenstein, William H. Brown, R. M. Mathews, Caroline Lefkowitz, A. Pelletier, W. J. Risley, J. C. Watkins, Effie S. Eby, *and* J. S. Byers.

602. *Proposed by Walter R. Warne, Dickinson College, Carlisle, Pa.*

P, Q, R sold 300 yards of cloth for \$900. P sold an unknown quantity at an unknown price and received \$300. Q sold an unknown quantity at one dollar per yard more than P and received \$300. R sold an unknown quantity at one dollar per yard more than Q and received \$300. Find the number of yards sold by each and their respective prices per yard.

Solution by Niel F. Beardsley, Evanston, Ill.

Let x = number yards P sold, and y = dollars per yard he received.
Let z = number yards Q sold.
Then

$$xy = 300$$

$$z(y+1) = 300$$

$$(300-x-z)(y+2) = 300$$

from which

$$y^3-4y-2 = 0, \quad \text{or} \quad y^3-Qy-R = 0.$$

From the identity $\cos^3\theta-(3\cos\theta)/4 = (\cos 3\theta)/4$, of which $\cos\theta$ is a root, we may, by putting $U = y\sqrt{3/4Q}$ and getting

$$U^3-3U/4-R\sqrt{27/64Q^3} = 0,$$

consider the two equations identical.

Then $U = \cos\theta$; $\cos 3\theta = R\sqrt{27/4Q^3}$; $y = \cos\theta\sqrt{4Q/3} =$

$$\sqrt{4Q/3}\cos[\cos^{-1}R\sqrt{(27/4Q^3)}/3]$$

Evaluating with values from our original equation, we get

$\theta = 16°30'+$ and $y = 2.214+$.

Horner's method will give the same result but for approximate values this seems shorter.

Finally, $x = 135.5$, $z = 93.34$.
P sold 135.5 yds. at 2.214 dollars per yard.
Q sold 93.34 yds. at 3.214 dollars per yard.
R sold 71.24 yds. at 4.214 dollars per yard.

Solutions were also received from Tuley, R. T. McGregor, A. Pelletier, Emily E. Chichester, C. F. W. McCready, Khimji Thakkur, Gertrude Buck, Walter R. Warne, Catherine Manion, Leo Blankenstein.

Geometry.

603. *Proposed by M. Costello, Brentwood, Calif.*

Describe a circle tangent to two given circles and passing through a given point.

Solution by R. M. Mathews, Duluth, Minn.

Analysis.—P is the point and O and O′ the circles of which O is the smaller. The required circle O″ will touch O and O′ in points M and N, respectively. Let MN cut O again in K and O′O in X. Let OO′ cut O in C and B and O′ in A *in this order from X*. Let PX cut O″ again in Q.

As the isosceles triangles OKM and O″MN have equal angles at M: OK||O′O″. Therefore CK||AN and

$\triangle$XCK is similar to XAN

But $\triangle$XCK is similar to $\triangle$XBM

$\therefore$ $\triangle$XBM is similar to $\triangle$XAN

and $XA \cdot XB = XM \cdot XN$.

But $XM \cdot XN = XP \cdot XQ$

$\therefore XA \cdot XB = XP \cdot XQ$

and the four points A, B, P, Q are concyclic.

As OK||O′N the point X is a center of similitude of circles O and O′.

Construction.—Draw two parallel radii OE, O′F and EF to cut OO′ in X. Draw the circle determined by ABP. It will cut XP in Q. Now the problem is reduced to the construction of a circle to pass through two points P, Q and to be tangent to a given circle O (or O′). As there are two solutions for that problem and two centers of similitude for O and O′ there are four circles through P tangent to O and O′. When the center of indirect similitude Y is taken, the letters B and C are to be interchanged. Then the preceding analysis holds and R is located concyclic with PA and (old) C, on PY.

In case the circles O and O′ are equal the line MN will be parallel to the line OO′ for the case of the center of direct similitude. But then O″ will lie symmetrically to the perpendicular bisector of OO′. Reflect P about this line to get Q, and proceed as before.

The maximum number of 4 solutions is not realized according as the circles intersect or one contains the other and according as the point lies within or on one.

Also solved by A. Pelletier (2), M. G. Schucker (2), Clifford N. Mills, Walter R. Warne, A. H. Gretsch *and two incorrect solutions were received.*

There seemed to be no departure from the conventional solution as stated above except by the use of conics. "Ruler and compass" solutions are desired. Some contributors mentioned the use of this construction in locating the German "super gun."—[Editor.

604. *Proposed by Khimji Thakkur, Urbana, Ill. (Formerly of Bombay, India.)*

ABC is an equilateral triangle of side 2 inches. Circles are described with A, B, C as centers, respectively, and radii 1 1/2 in. Describe a circle to have an internal contact with all the three circles. Determine the radius of this circle. By the theory of centers of similarity reduce the whole figure so that the outer circle may have a radius of 2 inches.

Solution by A. Pelletier, Montreal, Canada.

Let O be the center of the triangle. Then $OA = 2\sqrt{3}/3$. The radius, OAD, of the circle circumscribed about the three circles is evidently $2\sqrt{3}/3 + 3/2$.

To reduce the figure as required, take on OD a length, $OD' = 2$ inches. Describe a circle with O as center and OD′ as radius. From O′ draw any line cutting the concentric circles at M and M′, in order. Join AM, and from M′ draw M′A′ parallel to AM, and cutting OD at A′. The equilateral triangle A′B′C′ concentric to ABC is determined. Now $A'B' : AB = OA' : OA = OM' : OM = OD' : OD$, the required ratio. Moreover, from $OD : OD' = OA : OA'$ we derive $OD : OD' = AD : AD'$, hence the radius AD has been reduced to A′D′ in the proper ratio.

A solution was also received from J. C. Watkins.

Trigonometry.

605. *Proposed by W. W. Gorsline, Crane Junior College, Chicago.*

In the triangle ABC, if $\angle$A is twice $\angle$B, prove $a^2 = b^2+bc$.

I. *Solution by E. Kesner, Salida, Colorado.*

$a/b = \sin A/\sin B = 2\sin\frac{1}{2}A\cos\frac{1}{2}A/\sin\frac{1}{2}A = 2\cos\frac{1}{2}A$

$\therefore \cos\frac{1}{2}A = a/2b$

Also $b^2 = a^2+c^2-2ac\cos B$

$\therefore \cos B = (a^2+c^2-b^2)/2ac = \cos\frac{1}{2}A$

$\therefore a/2b = (a^2+c^2-b^2)/2ac$

Clearing of fractions,

$a^2(b-c) = b(b^2-c^2)$

or $a^2 = b(b+c)$.

II. *Solution by M. G. Schucker, Pittsburgh, Pa.* (By Geometry.)

From C drop a perpendicular p upon c at D. Let AD $= x$; then $2x+b = c$. [Since from C if a line CA$'$ = CA be drawn to meet AB in A$'$ we will have formed isosceles triangles ACA$'$ and CA$'$B.—*Ed.*] In the triangle ABC, $b^2 = p^2+x^2$. In the triangle BCD, $a^2 = p^2+(b+x)^2 = p^2+b^2+2bx+x^2$. Whence $a^2 = (p^2+x^2)+b^2+2bx$ and by substitution $a^2 = b^2+bc$.

III. *One of three solutions from A. Pelletier, Montreal, Can.*

We have

$\sin B\sin C = \sin B\sin(A+B) = \sin(A-B)\sin(A+B) = \sin^2A-\sin^2B$.

Hence, $\sin^2A = \sin^2B+\sin B\sin C$ and $a^2 = b^2+bc$.

Remark: The converse is true, *i. e.*, $a^2 = b^2+bc$ implies A = 2B.

Solutions were also received from R. Sciobereti, W. J. Risley, No Name, San Jose, Cal., S. H. Parsons, R. T. McGregor, C. E. Githens, R. M. Mathews (2), Walter R. Warne (2), Caroline Lefkowitz, Laura Guggenbuhl, R. V. Pritchard, A. H. Gretsch, *and* Murray J. Lenenthal.

Late Solutions.

Incomplete solutions to 586 and 588.

590. G. R. Narayana Ayya, Tinnevelly, India.

591, 592, 593. N. P. Pandya, K. Gopalau and B. HagaRajan.

598. Khimji Thakkur.

PROBLEMS FOR SOLUTION.

616. *Proposed by Daniel Kreth, Wellman, Ia.*

A and B, 171 miles distant from each other, travel toward each other until they meet. A travels one mile the first day, two miles the second, four miles the third, etc., while B travels 20 miles the first day, 18 miles the second, 16 miles the third, etc. Assuming that each day's journey by each of them is traveled at a uniform rate of speed, where will they meet?

617. *Proposed by E. Kesner, Salida, Col.*

Show that if n is any positive integer

$$2^{2n}+15n-1 \text{ is a multiple of 9.}$$

618. *Proposed by Walter R. Warne, Dickinson College, Carlisle, Pa.*

The Problem of Apollonius: Describe a circle tangent to three given circles.

619. *Proposed by Clifford N. Mills, Brookings, So. Dak.*

Given three points A, B and C, to find a fourth point P such that the areas of the triangles APB, APC, BPC shall be proportional to three lines L, M and N.

620. *Proposed by W. W. Gorsline, Chicago.*

In the triangle ABC $\angle$A is three times $\angle$B. Prove

$$bc^2 = (a+b)(a-b)^2 .$$

A PROPOSED POLAR EXPEDITION BY AIRPLANE.

Late in December of last year the plans were announced (e. g., *New York Times*, December 29, 1918) of a proposed polar expedition by airplane under the leadership of Captain Robert A. Bartlett, the well-known Arctic navigator, and with the support of the Aero Club of America. The plans call for the despatch of a vessel in June of this year to Etah, Greenland, which will serve as one of the main bases. From here a flying base is to be established at Cape Columbia, on the edge of the Polar Sea. Bases are also to be established at Cape Chelyuskin, Siberia, or on Nicholas II Land to the north of it, and at Wrangel Island. Within the triangle defined by these three points lies the greater part of the totally unexplored part of the Artic. The expedition will be equipped with a large plane, capable, for instance, of making the flight of 1,133 miles from Cape Columbia to Cape Chelyuskin, and several scout planes for shorter flights from the bases, such as from Cape Columbia to the Pole, a distance of 413 miles. In addition it is planned to send a small oil-burning vessel into the Polar Sea from Bering Strait and force her northward far enough so as to avoid the westward coastal current which carried the *Karluk*, in the hope that she will drift across the Pole and emerge on the European side. The expedition is planned to take three years.—[*Geographical Review*.

MOTION PICTURES FOR YOU.

During the war the United States Government spent millions of dollars in making motion pictures. These pictures show the service and sacrifice of those at the front and of those who worked at home.

The War Department alone has thousands of reels and hundreds of thousands of prints of these pictures and every returning ship brings more. These pictures belong to the people. They may be brought to every school, university, college, even to every cross-road school house, and shown free to the people at a nominal cost.

Questionnaires have been sent to 40,000 schools to locate those that have projection machines, and those that do not but have auditoriums or assembly rooms where pictures might be shown. Did you receive one of these questionnaires? If you have not returned it, please do so, and if you did not receive a blank, write for one to the Visual Instruction Section, Division of Educational Extension, Department of the Interior, Washington, D. C.—[*School Service*.

COAL AND PHOSPHATE IN SOUTHEASTERN IDAHO AND WESTERN WYOMING.

Coal has been mined in a small way in the Bighole Mountains, Teton County, Idaho, for many years, to supply the local demand. The coal is of excellent quality and the chief drawback to its wider use has been the remoteness of the mines from the railroad. During the war the greatly increased demand for fuel led to an increase of interest in this field, and late in 1918 preparations were being made to build a railroad spur to the mines from the Teton Valley Branch of the Oregon Short Line Railroad. When this track is completed Idaho may take a higher rating as a producer of coal.

The United States Geological Survey, Department of the Interior, has recently issued, as Bulletin 680, a report by A. R. Schultz, which describes the coal fields of the Bighole Mountains and other districts in this part of Idaho and the adjacent part of Wyoming. The report also describes extensive phosphate deposits in the same general region. The existence of these deposits has been known for more than 10 years, but

their extent was not known until they were mapped in detail and sampled by Mr. Schultz.

A copy of Bulletin 680 can be obtained on application to the Director of the United States Geological Survey, Washington, D. C.

PROSPECTIVE OIL TERRITORY IN NORTHWESTERN MONTANA.

Predictions that oil may be obtained from a certain geologic formation in an area hundreds of miles away from one in which it has yielded oil may be unfulfilled even though the geologic structure in the new area seems favorable. Nevertheless, if the conditions in such an area appear to be promising the oil prospector is warranted in maintaining a persistent optimism until fair tests with the drill at a reasonable number of favorable localities have shown that his hopes are unfounded. An optimistic outlook concerning the possibility that oil may be obtained from certain formations in a large area in Teton County and Lewis and Clark County, in northwestern Montana is expressed in a report prepared by Eugene Stebinger, of the United States Geological Survey, Department of the Interior, entitled "Oil and gas geology of the Birch Creek-Sun River area, northwestern Montana," and just published as the Survey's Bulletin 691-E.

The formations that yield most of the oil produced in Wyoming and all of the gas produced in Southern Alberta underlie nearly all of this area, and at places where the oil-bearing formations crop out at the surface the indications of oil are rather more numerous in northwestern Montana than in the oil-bearing regions of Wyoming.

PRODUCTION OF ALUMINUM IN 1918.

The value of the primary aluminum produced in the United States in 1918 as reported by the United States Geological Survey, Department of the Interior, was $41,159,225, a decrease of $4,722,775, or 10 per cent, from the value in 1917. The decrease is due very largely to a decline in the price of aluminum during 1918 and does not represent a corresponding decline in quantity of output.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 *Wilbur Ave., S. E., Cleveland, Ohio.*

Please send examination papers on any subject or from any source to the Editor of this department. *School examinations of all sorts are wanted. If you have run across anything queer, be sure to send it in.*

QUESTIONS AND PROBLEMS FOR SOLUTION.

325. *Proposed by John C. Packard, Brookline, Mass.*

WANTED—In **Physics and Chemistry,** a series of **live, up-to-date practical questions** as suggestions for the College Entrance Examination Board. Now is the time before copy is prepared for the 1920 papers.

326. *Proposed by the Editor.*

What is the proper relation between practical questions, and theoretical and book questions on an examination paper?

For instance, on the examination papers which follow **Physics A** is reckoned *theoretical* except the last part of 1, and the last part of 6 which are *practical,* and 2**b** which is *descriptive.* In **Physics B** the problems are *practical* (or imitations thereof).

Compare any 1918 examination paper with these papers of 1903 and express your opinion as to whether progress in question asking and examination making is indicated. If so, where?

[College examination questions are selected in this case because they (with the Regents' examinations of New York State) represent the nearest thing to standardized questions now available. Teachers' examinations should also be standardized, but very few such papers come to the Editor. Help him out by sending some. The above questions 325 and 326 are asked with the expectation that their discussion will lead toward *standardization of questions*.—EDITOR.]

327. Which questions in the Chemistry examination that follows are practical, which theoretical, which descriptive?

How many and which of these questions may be regarded as *standard*?

SCIENTIFIC FRESHMAN ENTRANCE EXAMINATIONS, PRINCETON UNIVERSITY PHYSICS.

Friday, June 12, 1903. 10:30 A. M.—12:30 P. M.

Any dishonesty in the examinations, including the giving as well as the receiving of aid, will, if detected, permanently debar the candidate from entering the University.

Note—Applicants presenting certified note-books will answer the questions under B only. Those not offering note-books must answer the questions under both A and B.

A.

1. What is a *force?* What is *energy?* What is *work?* What is the *Law of Gravitation?* What is *weight?* When a tumbler full of water is covered with a sheet of paper and inverted, why does not the water fall out?

2. a. What is *elasticity?* What is *Young's Modulus?* Describe its determination by the stretching of a wire.

b. Describe the phenomena which occur when a clean glass tube is dipped into water.

3. What is a *wave-motion?* What is a *sound-wave?* What is a *light-wave?* What is an *echo?* What is meant by the *interference* of sound?

4. State the arguments for believing that *heat* is a *form of energy*. When ice at 0°C is changed to water at 0°C, what becomes of the heat which is required for the change?

5. If two positive charges q^1 and q^2 are at distance R apart, what will be the *value* and *direction* of the *force* between them?

Outline briefly any experiment which proves that the *charge* of a *condenser* resides in the *dielectric*.

What is the law of the generation of heat in an electric circuit?

6. What is the *law of reflection* of light? What is meant by *refraction?* What is the *focal length* of a lens? Why is paper when wet more transparent than when dry?

ANY FIVE.

B.

1. A ball of mass 10 grams. is allowed to fall from rest. Where will it be at the end of 3 sec.? What will be its *velocity* at the end of the 5th sec.? Its *kinetic energy?* How far will it fall during the 10th sec.?

2. If the coefficient of friction is .4, what *force* is necessary to pull 100 kilos. up an inclined plane making 15° with the horizontal? How much *work* is done in drawing it 15 cm. along the plane?

$$\sin 15^\circ = .2588; \quad \cos 15^\circ = .9659$$

3. Two forks are sounding simultaneously, the lower fork making 256 vibrations per second. 9 beats are counted in 3 secs. What is the number of vibrations which the higher fork makes?

How does the velocity of sound in air vary with temperature?

4. 10 grams of steam at 100°C is turned into a vessel containing 100 grams of water at 20°C. The water equivalent of the vessel is 25. Neglecting the radiation losses, what will be the *resulting temperature?*

5. In an electrical circuit containing an electro-motive force of 16

volts, there is a total resistance of 80 ohms, 5 ohms between *A* and *B*. 15 between *B* and *C*, 45 between *C* and *D*, and 15 in the battery, what is the *current* in the circuit? What is the *difference of potential* between *C* and *D*?

How much heat is generated between *B* and *C* in 5 minutes?

What is the relation between the *joule* and the *watt?*

6. The *index of refraction* of a substance is 2.5 when the *angle of incidence* is 15°, show by a diagram what the angle of refraction will be.

A surface is illuminated by two lights, one of them being a standard candle. It is found that when the standard candle is at unit distance from the surface and the other light at distance 4.2, the surface is equally illuminated by the two lights. What is the candle-power of the second light?

ANY FIVE.

CHEMISTRY.

Friday, June 12, 1903. 10:30 A. M.—12:30 P. M.

Any dishonesty in the examinations, including the giving as well as the receiving of aid, will, if detected, permanently debar the candidate from entering the University.

State on the first page of your paper whether you have or have not had a course in laboratory chemistry. If you have had a course in laboratory chemistry your note book must bear the endorsement of your instructor and be handed in along with your paper.

1. What is meant by (a) chemical action and (b) physical change? Is chemical action always accompanied by physical change? In the following list of changes state which are of a chemical and which of a physical nature: Souring of milk, digestion of food, liquefaction of air, freezing and evaporation of water, grinding of grain, fading of colored fabrics, withering of leaves, weathering of rocks, melting of silver and solution of sugar in water.

2. What are the laws of constant and multiple proportions? Some examples which go to prove the validity of the laws.

3. Give an account of the atomic and molecular theories. By whom and for what reason was the atomic theory propounded? For what substances do the following signs stand? O_3, S, Si, SiO_2, NH_3, CH_4 $(NH_4)OH$, C_2H_2, P_4, HNO_3, Na_2CO_3, H_2O_2, Hg, N_2O, NO_2, Sb, As_2O_3, $FeSo_4$, H_2S, HF, $KAl(SO_4)_2$, $Na_2B_4O_7$, $Ca(OH)_2$, $Fe(OH)_3$ and $Sn(OH)_4$.

4. Sources, preparation (with equation), properties and importance of oxygen. Explain the terms combustion, oxidation, reduction, catalysis and nascent state.

5. How much chlorine by weight and by volume (at S. P. and S. T.) can be obtained from 100 grams of rock salt? Explain the roles played by chlorine and sulphur dioxide in bleaching.

6. Sources, preparation (with equation) properties and uses of carbon dioxide. Discuss the cycle of carbon in nature. Account for the formation of caves in limestone districts.

7. What is meant by the valence of the atom of an element? Valence formulas for the bromides, oxides, hydroxides and sulphides of sodium, zinc and ferric iron.

8. Define the terms base, acid and salt, and show how they are related. Express in the form of equations the reactions which occur when potassium hydroxide is neutralized with sulphuric acid, calcium hydroxide with hydrochloric acid and barium hydroxide with nitric acid.

9. Give an account of the methods for manufacturing soda according to the Le Blanc and Solvay (ammonia) methods. Uses of soda.

10. Ores, methods of smelting, properties and uses of *any* one of the following metals: Copper, zinc and lead.

$H = 1$, $Cl = 35.5$, $Na = 23$

NAVY AGAIN SEEKS MEN—ENLISTMENTS OPEN.

The Navy Recruiting Station, Transportation Bldg., Chicago, is enlisting a great number of young men each week, who are taking advantage of the many wonderful opportunities that the Navy is offering. Young men who have no special training may enlist and learn a valuable trade, such as machinists, electricians, etc.,

The machinist apprentice branch is open to young men between the ages of 18 and 35, who have had a small amount of shop experience. Men of this branch are transferred to the Machinist School, Charleston, S. C., where they are given a thorough and valuable course in machine work.

The electrician apprentice branch is open to young men between the ages of 18 and 30 who have a theoretical knowledge of electricity and who have had some practical experience in electrical work. A thorough course in electricity is given at the Electrical School, Hampton Roads, Va. Special literature covering this branch of the service will be furnished on request.

Young men between the ages of 18 and 25 who have a fair education may enlist in the Hospital Corps as Hospital Apprentice, 2nd Class. At the Hospital School, men of this branch are given a thorough elementary course in anatomy, first-aid, emergency-surgery, pharmacy, chemistry, compounding of medicines, etc.

Men of clerical ability are also wanted to enlist in the yeoman branch. The Navy Recruiting Station, Chicago, has complete literature covering all branches of the service that are at the present time open for enlistment. The Navy offers all young men, who are physically qualified, an opportunity to learn a trade and extensive travel. Write for further information or call at the above office, if convenient. Young men who are desirous of enlisting and live in a city where there is no recruiting station, will be furnished free transportation to the nearest station, upon request.

BOOKS RECEIVED.

The Winston Simplified Dictionary, edited by W. D. Lewis and E. Singer. Illustrated. Pages iv+820. 12.5×19 cm. Cloth. 1919. The John C. Winston Company, Philadelphia.

Vocational Civics, by F. M. Giles, Principal High School, DeKalb, Ill., and Imogene Kean Giles, High School, Cicero, Ill. Pages 252. 12.5×17 cm. 1919. The Macmillan Company, New York. Cloth. $1.30.

Textiles and Clothing, by Ellen Beers McGowan, Teachers College, Columbia University, and Charlotte A. Waite, Richman High School, New York. Pages 267. 12.5×17 cm. Cloth. $1.30. The Macmillan Company, New York.

Final Report of the National Army Training Detachments, Later known as Vocational Section, S. A. T. C., by C. R. Dooley, Educational Director Vocational Instruction. 177 pages. 22×28 cm. Paper. 1919. War Department, Washington, D. C.

Class book of Economic Entomology, by William Lochhead, McGill University. Pages xiv+436. 14×20 cm. Cloth, 1919. $2.50. P. Blakiston's Son & Company, Philadelphia.

New High School Arithmetic, Academic, Industrial, Commercial, by Webster Wells and Walter W. Hart, University of Wisconsin. Pages viii+358. 12×18 cm. Cloth. 1919. D. C. Heath & Company., Chicago.

A Laboratory Course in Physics of the Household, by Carleton J. Lynde, Macdonald College, Canada. Pages xv+146, 13×19 cm. Cloth. 1919. 90 cents. The Macmillan Company, New York City.

Elements of Plane Trigonometry, with complete tables, by Alfree M. Kenyon, Purdue University, and Louis Ingold, University of Missouri. Pages ix+117+xviii+124. 13×20 cm. Cloth, 1919. $1.20. The Macmillan Company, New York City.

Elements of Plane Trigonometry, with brief tables, same author as above. Pages ix+117+xviii+12. 13×20 cm. Cloth. 1919. $1.00. The Macmillan Company, New York City.

BOOK REVIEWS.

Science of Plant Life, by Edgar Nelson Transeau, Ohio State University. Cloth. 336XIX pages. 13x19 cm. 194 illustrations. World Book Company, 1919

This book presents a very pleasing appearance in binding, typography and illustrations. It has 120 original drawings by one artist, a very unusual occurrence in bookmaking. Moreover, the drawings are excellent, expressive and well chosen. We were highly pleased when we first looked into the book, it is so unusual. Here we thought is a high school text in botany that has dared to depart from the threadbare type method of approach—and by a college professor at that. We still marvel much at the book, but not so much as at first sight.

The author has, indeed, departed from the usual method of treatment through something over 200 pages, but he relapsed finally and we find the old evolutionary series at the end with about 100 pages. The central thought through the studies of seed plants is the plant and its response to its environment. On the whole this is well done, but not well balanced —note eleven pages given to leaf coloration and the fall of leaves.

We do not believe with the author that the fundamentals of gardening, forestry, plant breeding, and other topics of this sort should find no place in high school botany. A well known college man said in an address to high school teachers recently that the fundamental principles of botany may be derived as well from agricultural and garden plants as from other plants, strange to the student and unrelated in their habit to the every day life of the student. He was right. Why not make the study of botany center around familiar and useful plants? Why not make the study of weeds yield up some of the principles of botany? They are there all right in goodly number.

We advise teachers to examine this book carefully. It has some excellent features. Whether it would be a good class book we are not sure. The style seems somewhat involved for tenth grade pupils to grasp. A trial will tell the story in this respect. W. W.

Farm Science, a Foundation Text Book of Agriculture, by W. J. Spillman, United States Department of Agriculture. Cloth. 13x18 cm. 344+VII pages. Illustrated with 174 figures and maps. World Book Company, 1918.

This book is announced as the first of a new series of agricultural textbooks, edited by Mr. Spillman. It is intended to meet the need of the small high school in the country districts, for a foundational course in agriculture. It is written simply and carefully, but does not dodge important fundamental principles. The subject matter is well chosen and covers the field in a thorough manner. It is divided into four parts: The soil, the plant, the animal, and the farm.

The illustrations are good and instructive as well as plentiful. With each chapter are summaries and suggestions for observation and experiment. These also are excellent and practical for the type of school for which the book is intended.

We feel that the author has prepared a successful textbook, one which will wear well in use. May we have more such books? They are needed.

W. W.

The Living Cycads, by Charles Joseph Chamber, University of Chicago. Cloth. Size 13x17 cm. 172+XIV pages, with 91 illustrations. Published by University of Chicago Press. 1919. Price $1.50.

This book is published in the University of Chicago Science Series and is a brief nontechnical account of fifteen years' research work on the Cycads. These plants occupy a strategic point between the spore plants and the seed plants. It is this importance of the living Cycads with an ancestry that may be traced back through geological periods of the earth's history that has led the author to devote so many years to their study and travels to Cuba, Mexico, Africa and Australia for study of the plants in their native habitats and supplies of material for laboratory research.

The book is divided into three parts: An account of the distribution, general appearance, and field conditions of the Cycads; the life history of the group; the evolution and phylogeny of the cycads. The descriptions and statements of the author are based upon personal investigations of the plants in the field and in the laboratory. The illustrations are from original drawings and photographs. This is an example of a good piece of work pursued faithfully through many years, in a well chosen field. We need more work of this sort. It may well serve as a good example of scientific method of investigation for others who aim at original investigation.

W. W.

DIRECTORY OF SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the March, June, and October issues of this Journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. This is extremely valuable information to all progressive teachers. Is your Society listed here? Names are dropped when they become one year old.

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H.—*Anthropology and Psychology*, Lt. Col. E. K. STRONG, JR., Room 528, State, War and Navy Bldg., Washington, D. C.

I.—*Social and Economic Science*, SEYMOUR C. LOOMIS, 82 Church St., New Haven, Conn.

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AMERICAN SOCIETY OF ZOOLOGISTS.

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AMERICAN SOCIETY OF NATURALISTS.

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ASSOCIATION OF AMERICAN GEOGRAPHERS.

President, Charles R. Dryer; *First Vice-President*, Dr. Herbert E. Gregory; *Second Vice-President*, Dr. Isaiah Bowman; *Secretary*, Dr. Oliver L. Fassig; *Treasurer*, Francois E. Matthes.—1219.

Association of Teachers of Mathematics in the Middle States and Maryland.

President, Herbert E. Hawkes, Columbia University; *Vice-President*, Emma M. Requa, Hunter College; *Secretary*, W. Burton Walsh, Ethical Culture School, N. Y.; *Treasurer*, H. Ross Smith, Southern High School, Philadelphia.—1219.

Central Association of Science and Mathematics Teachers. (*Annual meeting, November 27, 28, and 29, 1919, at the Lake View High School, Chicago.*)

President, Jerome Isenberger, Senn High School, Chicago; *Vice-President*, Fred T. Ullrich, Normal School, Platteville, Wis.; *Secretary*, Harry O. Gillet, School of Education, University of Chicago; *Corresponding Secretary*, D. A. Lehman, Perdue University, LaFayette, Ind.; *Treasurer*, John H. McClellan, Harrison Technical High School, Chicago; *Assistant Treasurer*, G. H. Crandall, Culver, Ind.; *Chairman of Biology Section*, Clarence L. Holtzman, Waller High School, Chicago; *Secretary*, William E. Howard, High School, Ottawa, Ill.; *Chairman of Chemistry Section*, S. R. Wilson, Culver, Ind.; *Secretary*, H. M. Mess, Senn High School, Chicago; *Chairman Earth Science Section*, W. F. Headley, Austin High School, Chicago; *Secretary*, Alberta Drew High School, Joliet, Ill.; *Chairman General Science Section*, Fred D. Barber, Normal University, Normal, Ill.; *Secretary*, Ada L. Wechel, High School, Oak Park, Ill.; *Chairman Home Economics Section*, Katherine Blunt, University of Chicago; *Secretary*, Grace Hood, University of Cincinnati; *Chairman of Mathematics Section*, Byron Cosby, Normal School, Kirksville, Mo.; *Secretary*, Miss E. G. Parker, High School, Oak Park, Ill.; *Chairman of Physics Section*, F. R. Gorton, Normal School, Ypsilanti, Mich.; *Secretary*, A. W. Augur, Tilden High School, Chicago.—1118.

Chemistry Teachers' Club of New York City.

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Ecological Society of America.

President, Barrington Moore, American Museum of Natural History; *Vice-President*, T. L. Hankinson, Eastern Illinois State Normal School; *Secretary-Treasurer*, Forrest Shreve, Desert Laboratory.—1218.

General Science Club of New England.

President, Walter G. Whitman, Normal School, Salem, Mass.; *Vice-President*, Richard T. Lunt, English High, Boston, Mass.; *Secretary*, Sumner Marvel, High School, New Bedford, Mass.; *Treasurer*, Charles Stone, English High, Boston, Mass.—1219.

Geological Society of America.

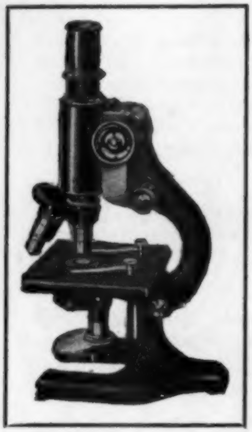
President, John C. Merriam, University of California, Berkeley, Cal.; *First Vice-President*, R. A. F. Penrose, Jr., 460 Bullitt Bldg., Philadelphia, Pa.; *Second Vice-President*, Herbert E. Gregory, Yale University, New Haven, Conn.; *Third Vice-President*, Robert T. Jackson, Peterborough, N. H.; *Secretary*, Edmund Otis Hovey, American Museum of Natural History, New York City; *Treasurer*, Edward B. Mathews, Johns Hopkins University, Baltimore, Md.; *Editor*, Joseph Stanley-Brown, 26 Exchange Place, New York City.—1218.

Illinois Academy of Science.

President, Henry B. Ward, University of Illinois; *Vice-President*, Geo. D. Fuller. University of Chicago; *Secretary*, J. L. Pricer, State Normal University, Normal; *Treasurer*, W. G. Waterman, Northwestern University.—319.

Iowa Academy of Science.

President, S. W. Beyer, Iowa State College, Ames; *First Vice-President*, T. C. Stephens, Morningside College, Sioux City; *Second Vice-President*, R. Monroe McKenzie, Parsons College, Fairfield; *Secretary*, James H. Lees, Iowa Geological Survey, Des Moines; *Treasurer*, A. O. Thomas, State University, Iowa City.—318.



IOWA ASSOCIATION OF SCIENCE TEACHERS.

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IOWA ASSOCIATION OF MATHEMATICS TEACHERS.

President, E. E. Watson, Parsons College, Fairfield, Iowa; *Vice-President*, Maria M. Roberts, Iowa State College, Ames, Iowa; *Secretary-Treasurer*, Ira S. Condit, Iowa State Teachers College, Cedar Falls, Iowa.—1218.

KANSAS ASSOCIATION OF MATHEMATICS TEACHERS.

President, Prof. T. E. Mergendahl, College of Emporia, Emporia, Kan.; *Vice-President*, Miss Eleanora Harris, Hutchinson, Kan.; *Secretary-Treasurer*, Prof. J. A. G. Shirk, State Manual Training Normal, Pittsburg, Kan.—1218.

MATHEMATICAL ASSOCIATION OF AMERICA.

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OHIO ASSOCIATION OF TEACHERS OF MATHEMATICS AND SCIENCE.

President, J. C. Boldt, Stiver's High School, Dayton, Ohio; *Secretary-Treasurer*, H. M. Beatty, Ohio State University, Columbus, Ohio.—1218.

SOUTHERN CALIFORNIA SCIENCE AND MATHEMATICS ASSOCIATION.

President, Agnes Wolcott, High School, Long Beach; *Vice-President*, E. E. Chandler, Occidental College; *Secretary-Treasurer*, N. D. Knupp, High School, Santa Monica; *Chairman of Mathematics Section*, Paul Arnold, University Southern California; *Chairman of Biology Section*, L. R. Langworthy, Manual Arts High School, Los Angeles; *Chairman of Earth Science Section*, Helen V. Peasley, Fourteenth Street Intermediate, Los Angeles; *Chairman of Physics-Chemistry Section*, A. Haven Smith, Junior College, Riverside.—1218.

WASHINGTON ACADEMY OF SCIENCES.

President, F. L. Ransome; *Vice-Presidents, Anthropological*, Geo. M. Kober; *Archaeological*, A. Hrdlicka; *Biological*, Hugh M. Smith; *Botanical*, W. T. Swingle; *Chemical*, A. Seidell; *Electrical Engineers*, P. G. Agnew; *Engineers*, Morris Hacker; *Entomological*, S. A. Rohwer; *Foresters*, Raphael Zon; *Geographic*, O. H. Tittmann; *Geological*, F. H. Knowlton; *Historical*, Allen C. Clark; *Medical*, Wm. Gerry Morgan; *Philosophical*, W. J. Humphreys; *Corresponding Secretary*, R. B. Sosman; *Recording Secretary*, W. R. Maxon; *Treasurer*, R. L. Faris.—119.